MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Robert L. Ehrlich, Jr., *Governor*
Michael S. Steele, *Lt. Governor*
C. Ronald Franks, *Secretary*

Maryland Tributary Strategy Upper Potomac River Basin Summary Report for 1985-2003 Data

January 2005

Tawes State Office Building • 580 Taylor Avenue • Annapolis, Maryland 21401
410.260.8DNR or toll free in Maryland 877.620.8DNR • TTY users call via Maryland Relay

Maryland Tributary Strategy Upper Potomac River Basin Summary Report for 1985-2003 Data
January 2005

Prepared by: Chesapeake Bay Program Tidal Monitoring and Analysis Workgroup
Contributions from:
Beth Ebersole, Bill Romano, Kevin Coyne, Tom Parham, Lee Karrh, and Renee Karrh,
Maryland Department of Natural Resources
Roberto Llansó, Versar, Inc.
Richard Lacouture, Morgan State University

Contact: Bill Romano, Maryland Department of Natural Resources

Maryland Department of Natural Resources
Tawes Building, D-2
580 Taylor Avenue
Annapolis, MD 21401
bromano@dnr.state.md.us

Website Address:
http://dnr.maryland.gov

Toll Free in Maryland:
1-877-620-8DNR, ext: 8630
Out of state call: 410-260-8630
TTY users call via the MD Relay:
711 (within MD)
Out of state call: 1-800-735-2258

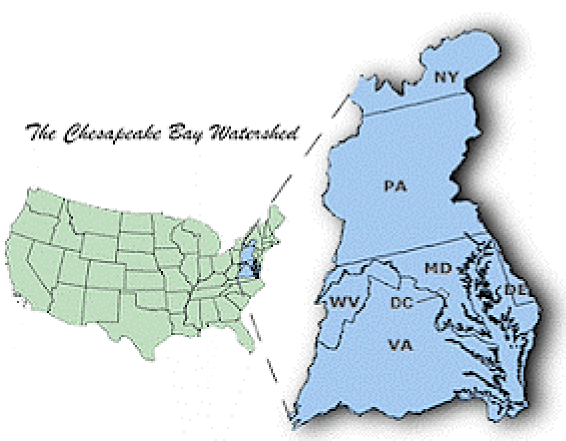
Introduction

The Chesapeake Bay is the largest estuary in North America. A national treasure, the Bay is famous for providing delicious seafood as well as a myriad of recreational and livelihood opportunities, such as boating, fishing, crabbing, swimming, and bird-watching.

By the 1970s, however, our treasured Bay was in serious decline. In 1975, the United States Congress directed the Environmental Protection Agency (EPA) to conduct a comprehensive study of the most important problems affecting the Chesapeake Bay. The findings of this study formed the crux of the first Chesapeake Bay Agreement, signed in 1983 by Maryland, Virginia, Pennsylvania, Washington DC, the Chesapeake Bay Commission and the EPA. Additional scientific information gained from monitoring data and modeling efforts was used to amend that Agreement, resulting in the 2000 Chesapeake Bay Agreement (http://www.chesapeakebay.net/agreement.htm).

Science showed that three of the biggest problems facing the health of the Chesapeake Bay and its tributaries (the rivers and streams that flow into the Bay) are excess nitrogen, phosphorus, and sediments. The nutrients nitrogen and phosphorus fuel excessive algae growth. These algae, as well as suspended sediments, cloud the water and prevent Bay grasses from getting enough light; Bay grasses provide essential habitat for crabs and fish as well as food for waterfowl. When algae blooms die, they decompose using up essential oxygen. This lack of oxygen kills bottom-dwellers such as clams and sometimes fish. Another problem with excess nutrients is that they sometimes favor the growth of harmful algae. Harmful algae can be toxic to aquatic animals and even humans. For more details on the Bay's ecosystem and the problems facing it, see http://www.dnr.state.md.us/Bay/monitoring/mon_mngmt_actions/monitoring_mgmt_actions.html.

Figure UPR1



The health and vitality of the Chesapeake Bay is a product of what happens in the watershed, the land area that drains into it. The Chesapeake Bay watershed covers 64,000 square miles, and includes land in six states plus Washington DC (Figure UPR1).

To help achieve Maryland's share of the reductions in nitrogen, phosphorus, and sediment to the Bay and its tributaries, a Tributary Strategy Team has been appointed for each of the ten Chesapeake Bay sub-watersheds in Maryland:

- Upper Western Shore Basin
- Patapsco/Back Rivers Basin
- Lower Western Shore Basin
- Patuxent River Basin
- Upper Potomac River Basin
- Middle Potomac River Basin
- Lower Potomac River Basin
- Upper Eastern Shore Basin
- Choptank Basin
- Lower Eastern Shore Basin

Each team is comprised of business leaders, farmers, citizens, and state and local government representatives who work together to identify the best ways to reduce nutrient and sediment inputs to the Bay.

This report provides:

- Upper Potomac River basin characteristics
- Nutrient and sediment loadings to the Upper Potomac River based on model results (the model is developed using monitoring data)
- Overview of monitoring results
    - links to in-depth non-tidal water quality information
    - non-tidal water quality status and trends (based on monitoring data, i.e., measured concentrations from 1985 to 2003)
- individual wastewater treatment plant outputs

The goal of this report is to show current status of the habitat and water quality (how good or bad it is) and long-term trends (how has water quality and habitat improved or worsened since 1985) provided within the context of information about the basin.

Upper Potomac River Basin Characteristics

The Upper Potomac River Basin is the largest in the State and drains 2,050 square miles of land including all of Allegany and Washington Counties and parts of Montgomery, Frederick, Carroll, and Garrett Counties. The basin lies in the Appalachian Plateau Province, the Ridge and Valley Province, the Blue Ridge Province, and the Lowland Section of the Piedmont Plateau Province. Larger water bodies include the Potomac, North Branch Potomac, and Monocacy Rivers, and Catoctin, Antietam, Conococheague, Town, Wills, and Georges Creeks. There are numerous lakes in the basin, including Seneca Lake (the largest), Lake Habeeb, Savage River Reservoir, and Jennings Randolph Reservoir.

The projected human population for the basin in 2000 was 462,167, with approximately 181,410 housing units. The population density is moderate compared to the other tributary strategy basins. Major population centers in the basin include Frederick, Hagerstown, Cumberland, Westminster, and Green Valley.

The Maryland Department of Planning land use categories are defined as follows (Figure UPR2):

- urban – includes residential, industrial, institutional (such as schools and churches), mining, and open urban lands (such as golf courses and cemeteries)
- agriculture – includes field, forage, and row and garden croplands; pasturelands; orchards and vineyards; feeding operations; and agricultural building/breeding and training facilities, storage facilities, and built-up farmstead areas
- forest – includes deciduous forest, evergreen forest, mixed forest, and brush
- water – includes rivers, waterways, reservoirs, ponds, and the Bay
- wetlands – includes marshes, swamps, bogs, tidal flats, and wet areas
- barren – includes beaches, bare exposed rock and bare ground

According to the Maryland Department of Planning 2000 information, the predominant land use in the Upper Potomac River Basin is classified as forested (48 percent). Agricultural land is the second largest land use at 38 percent. Approximately 14 percent of the basin is classified as urban land (Figure UPR2).

A series of Best Management Practices (BMPs) have been planned in the basin to help reduce non-point source pollution. As of 1998, the implementation of these practices varies from having exceeded the goal to not having made any progress. Implementation of BMPs for animal waste management, conservation tillage, cover crops, and stream buffers have made good progress toward Tributary Strategy goals. Unfortunately, there has been no progress in forest harvesting BMPs, which consist of regulatory and voluntary measures applied to timber harvests, including erosion and sediment control and streamside management. Others, such as nutrient management and stream protection have exceeded the goals.

There are 18 major (design flow of half a million gallons per day or greater) and 63 active minor wastewater treatment plants in the basin. (The Nicodemus plant has been decommissioned and flow is now diverted to the Conococheague facility.) Eleven of the major wastewater treatment plants have already implemented biological nutrient removal (BNR). BNR is considered advanced wastewater treatment and removes excess nitrogen. One major plant plans to implement BNR by 2005, and three by 2010. The remaining three major plants have not planned to implement BNR. The locations of major and minor plants are shown in Figure UPR3. Appendix A contains graphs of nutrient loads from the basin's major wastewater treatment facilities.

The Chesapeake Bay Program model categorizes nutrient and sediment loads from both point sources (end of pipe inputs from wastewater treatment plants and industrial outfalls) and non-point sources. The non-point loads are estimated from a variety of sources including land cover, agriculture records, etc. Generally, the categories in Figures UPR4-UPR6 include:

- point sources – out of pipe from waste water treatment plants and industrial releases
- non-point sources
    - urban – from industrial, residential, institutional, mining and open urban lands
    - agriculture –from row crop, hay, pasture, manure acres
    - forest –from forested lands
    - mixed open –from non-agricultural grasslands including right-of-ways and some golf courses
    - atmospheric deposition to water – deposited from the atmosphere directly to water

For more detailed information, see the document *Chesapeake Bay Watershed Model Land Use Model Linkages to the Airshed and Watershed Models* at http://www.chesapeakebay.net/pubs/1127.pdf.

As of 2002, the Chesapeake Bay Program Phase 4.3 Model indicated that the most significant contributor of nitrogen in the Upper Potomac River basin was agriculture (56 percent) followed by point sources (18 percent) (Figure UPR4). For phosphorus, the largest contributor was agriculture (59 percent), followed by point sources (22 percent) (Figure UPR5). Agriculture was also the dominant source of sediments (80 percent) (Figure UPR6).

Figure UPR2 - 2000 Land use in the Upper Potomac River Tributary Strategy Basin

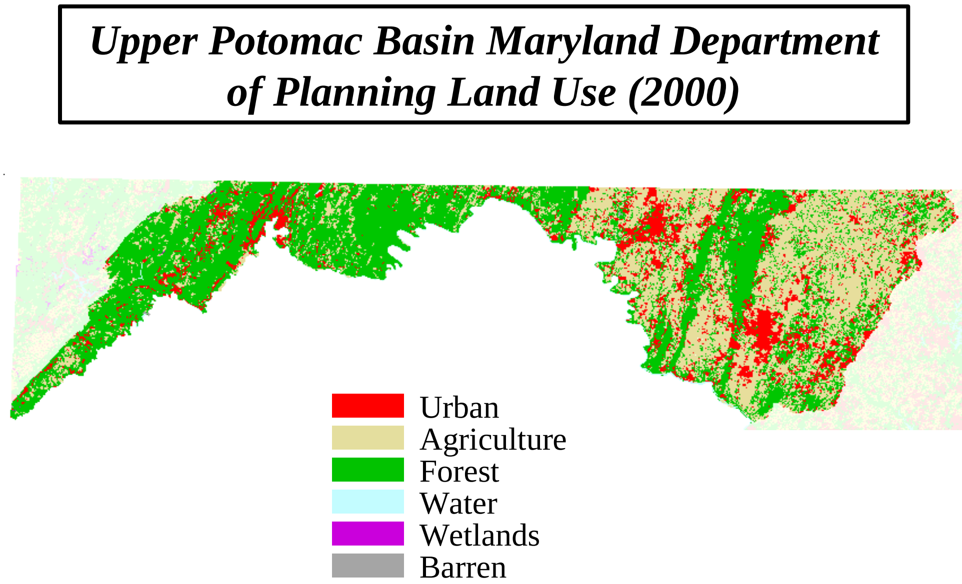


Figure UPR3 – Wastewater treatment plants in the Upper Potomac River Tributary Strategy Basin

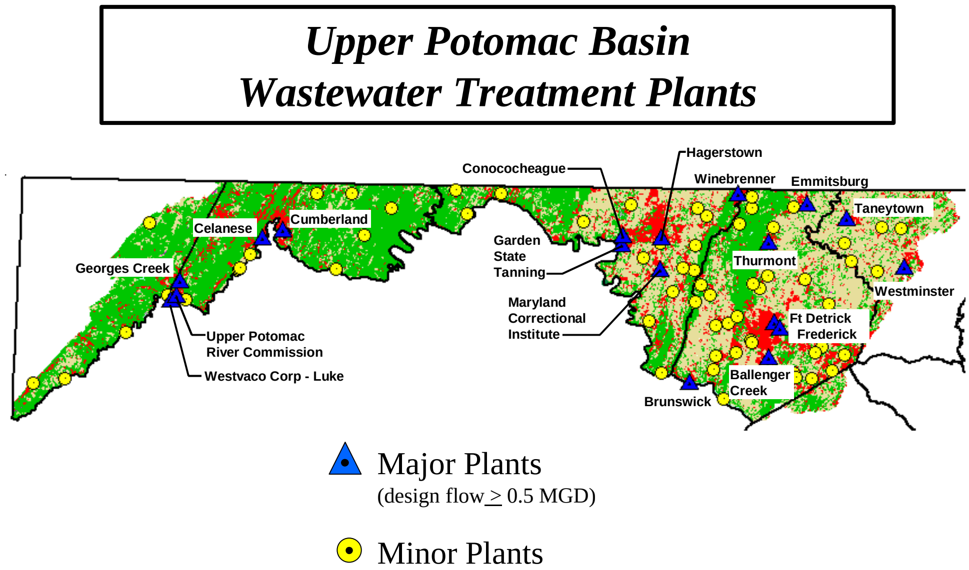
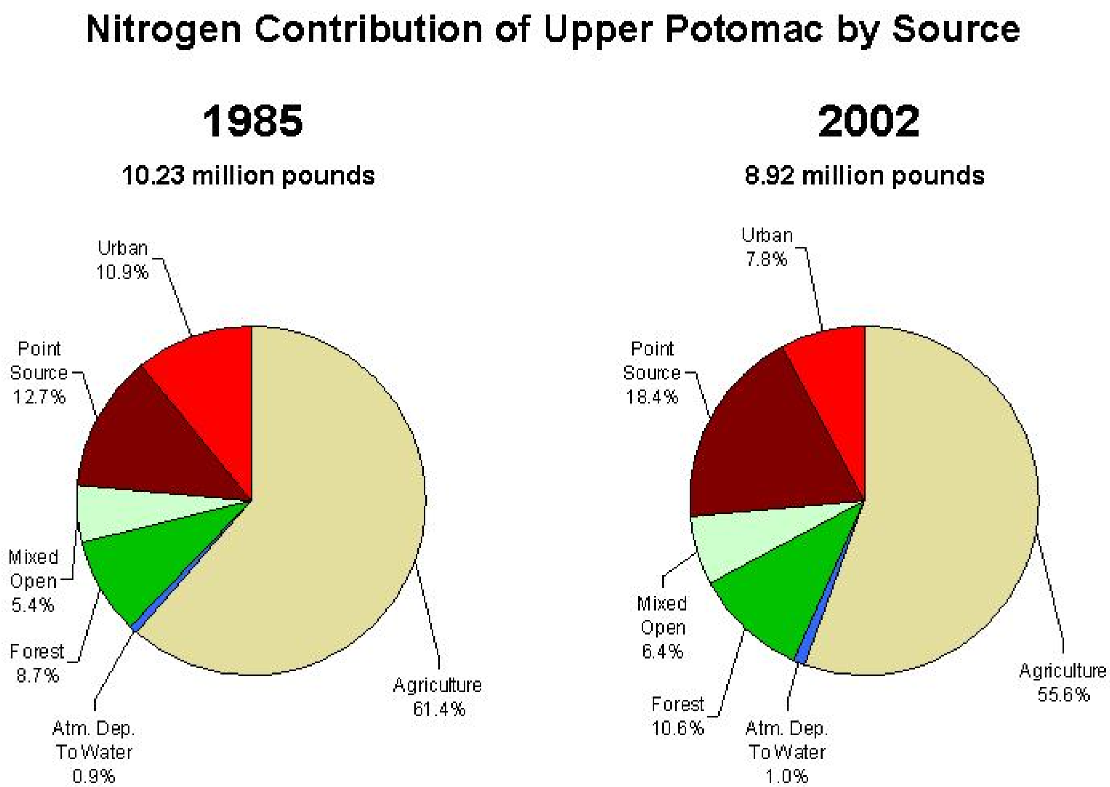


Figure UPR4 – 1985 and 2002 Nitrogen Contribution to the Upper Potomac River by Source.



Source: Chesapeake Bay Program Phase 4.3 Watershed Model

Figure UPR5 – 1985 and 2002 Phosphorus Contribution to the Upper Potomac River by Source.

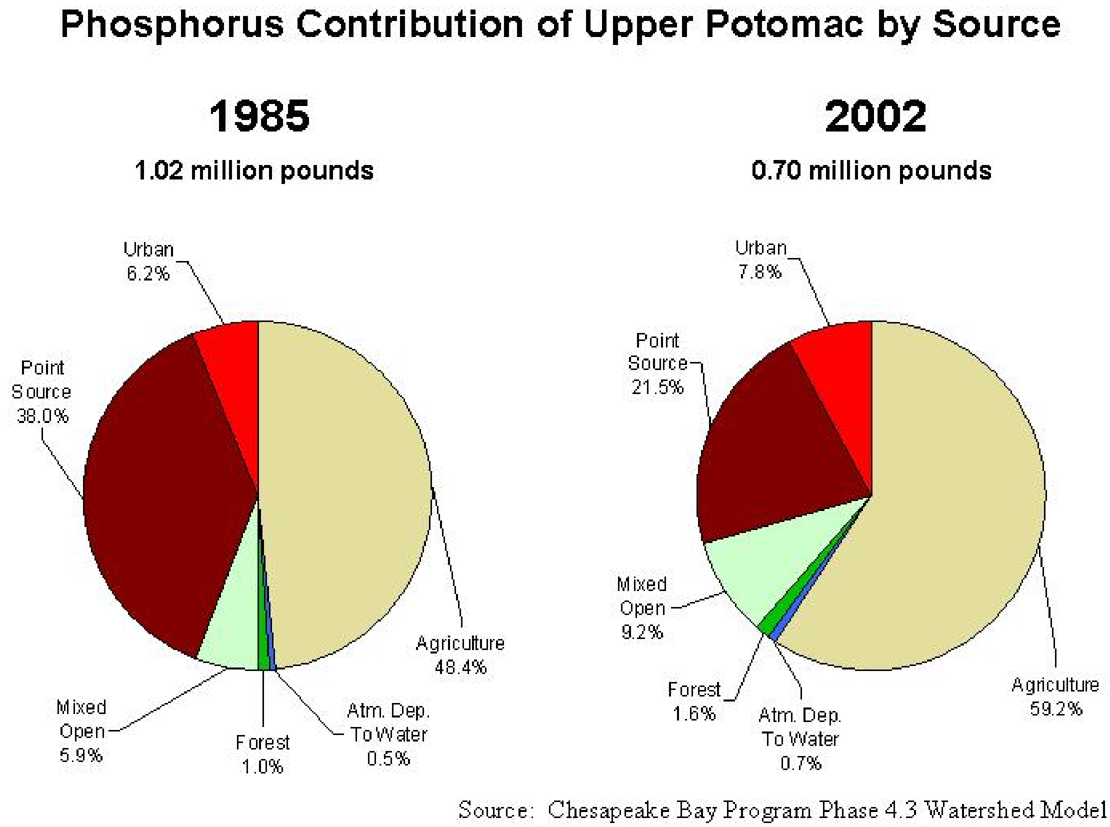
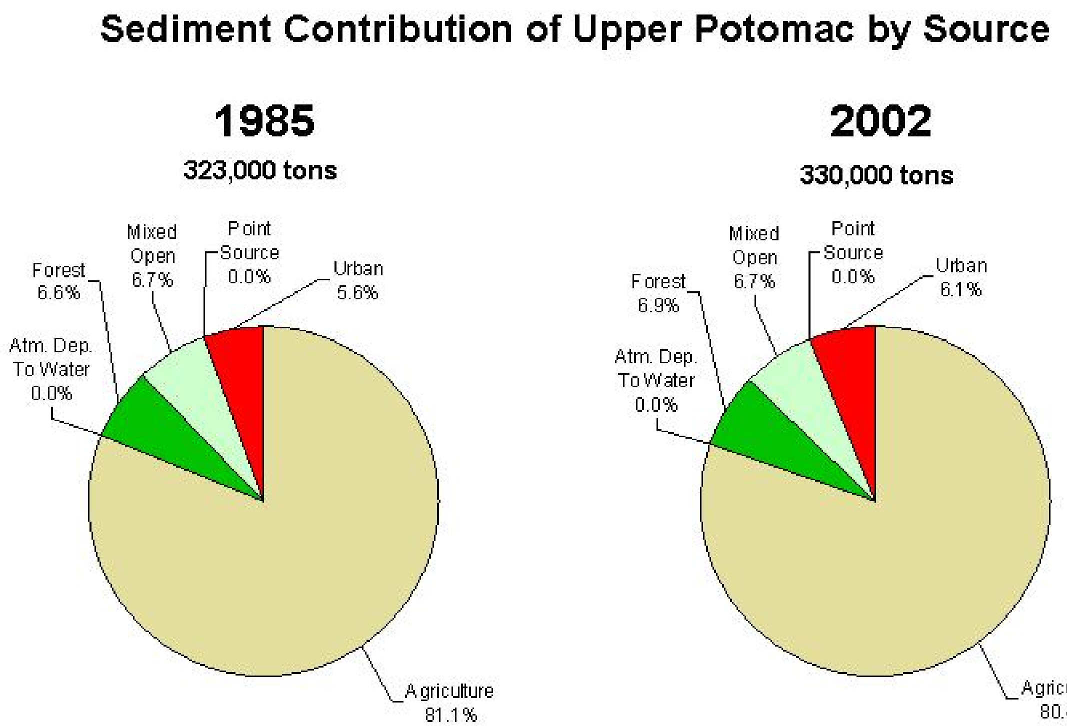


Figure UPR6 – 1985 and 2002 Sediment Contribution to the Upper Potomac River by Source.



Source: Chesapeake Bay Program Phase 4.3 Watershed Model

Overview of Monitoring Results

Water and Habitat Quality

Water Quality Monitoring Information Sources

Much useful information on non-tidal water quality is available on the Internet. The State of Maryland's Biological Stream Survey (MBSS) basin fact sheets and basin summaries are available at:
http://www.dnr.state.md.us/streams/mbss/mbss_fs_table.html
MBSS also reports stream quality information summarized by county at:
http://www.dnr.state.md.us/streams/mbss/county_pubs.html. In addition to these reports and fact sheets, detailed and more recent information and data are also available on the MBSS website: http://www.dnr.state.md.us/streams/mbss.

Water quality information collected by Maryland's volunteer Stream Waders is available at: http://www.dnr.state.md.us/streams/mbss/mbss_volun.html.

Information on the Frederick County Clean Stream Program can be found at:
http://www.co.frederick.md.us/NPDES/h2oquality.html.

Information on the Monocacy Basin Stream Monitoring Project can be found at:
http://www.hood.edu/academic/biology/monocacy/

For information on environmental programs in Montgomery County click on the following web address, then Departments, then Environmental Protection:
http://www.montgomerycountymd.gov/

Water quality and stream flow data are also available from the U.S. Geological Survey at:
http://md.water.usgs.gov/

Long-term Non-Tidal Water Quality Monitoring

Good water quality is essential to support the animals and plants that live or feed in the rivers, lakes, and streams of the Upper Potomac River Tributary Strategy Basin. Important water quality parameters are measured at 28 long-term monitoring stations. Parameters measured include nutrients (nitrogen and phosphorus) and total suspended solids.

Current status is determined based on the most recent three-year period (2001-2003). State thresholds have not been established for total nitrogen, total phosphorus, and total suspended solids, although a water quality criteria document has been completed by the Chesapeake Bay Program—http://www.chesapeakebay.net/baycriteria.htm—and new water quality criteria (for dissolved oxygen, water clarity, and chlorophyll) are currently being developed by the Maryland Department of the Environment—
http://www.mde.state.md.us/ResearchCenter/Data/waterQualityStandards/index.asp.

Until the new water quality criteria have been approved, the current data through 2003 are compared to a baseline data set, and assigned a status of good, fair, or poor, which is only a *relative* status compared to the baseline data. Trends are determined using a non-parametric test for trend (the Seasonal Kendall test). For a detailed description of the methods used to determine status and trends, see http://www.dnr.state.md.us/Bay/tribstrat/status_trends_methods.html**.**

Total nitrogen status at all stations in the western section of the basin is good. Total nitrogen status in the eastern section, which has more urban areas and more land in agriculture, is generally poor. Total phosphorus status is also generally good in the western section of the basin and poor at almost all stations in the eastern section. Total suspended solids status was generally fair or poor in both the eastern and western sections of the basin (Figures UPR7-UPR12).

Figure UPR7 – Total Nitrogen Concentrations in the Upper Potomac River Basin (western)

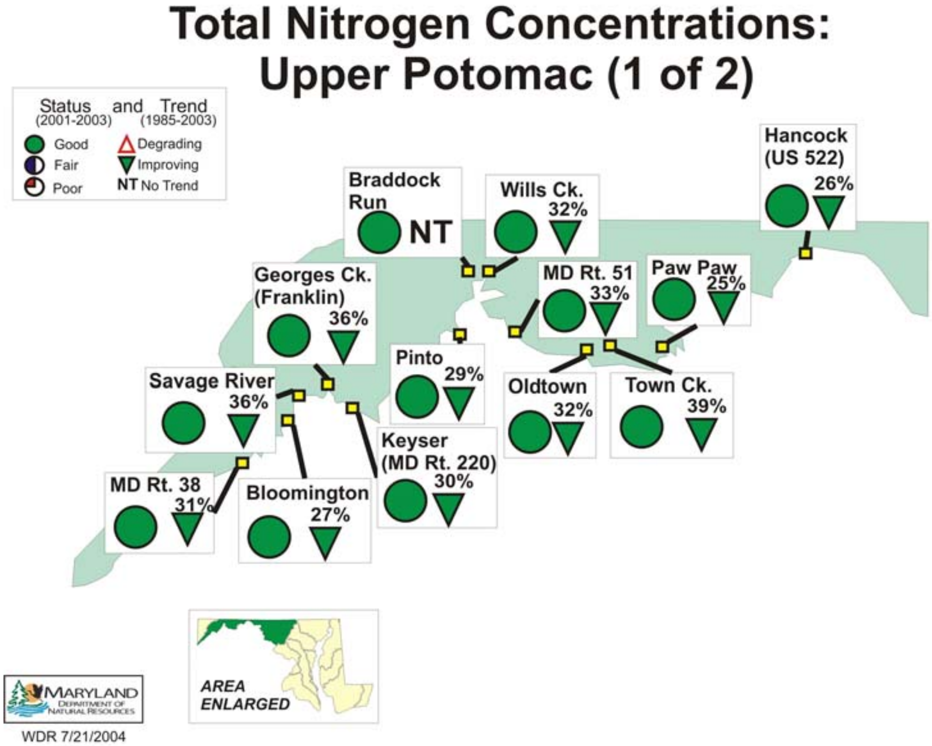


Figure UPR8 – Total Nitrogen Concentrations in the Upper Potomac River Basin (eastern)

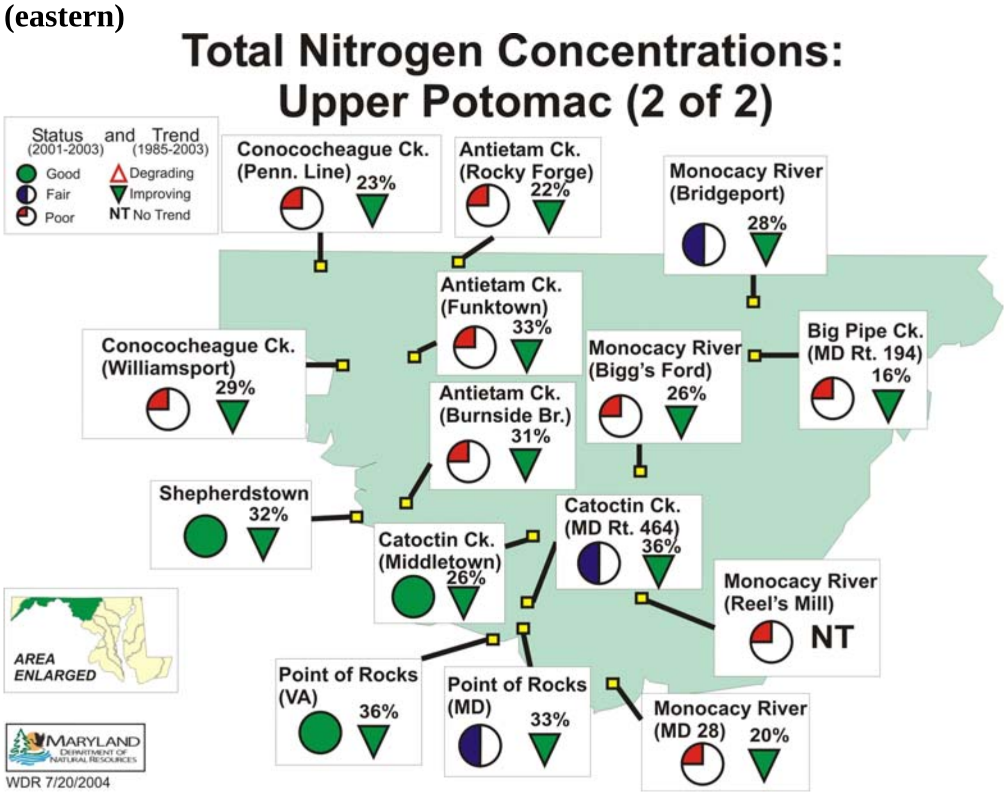


Figure UPR9 – Total Phosphorus Concentrations in the Upper Potomac River Basin (western)

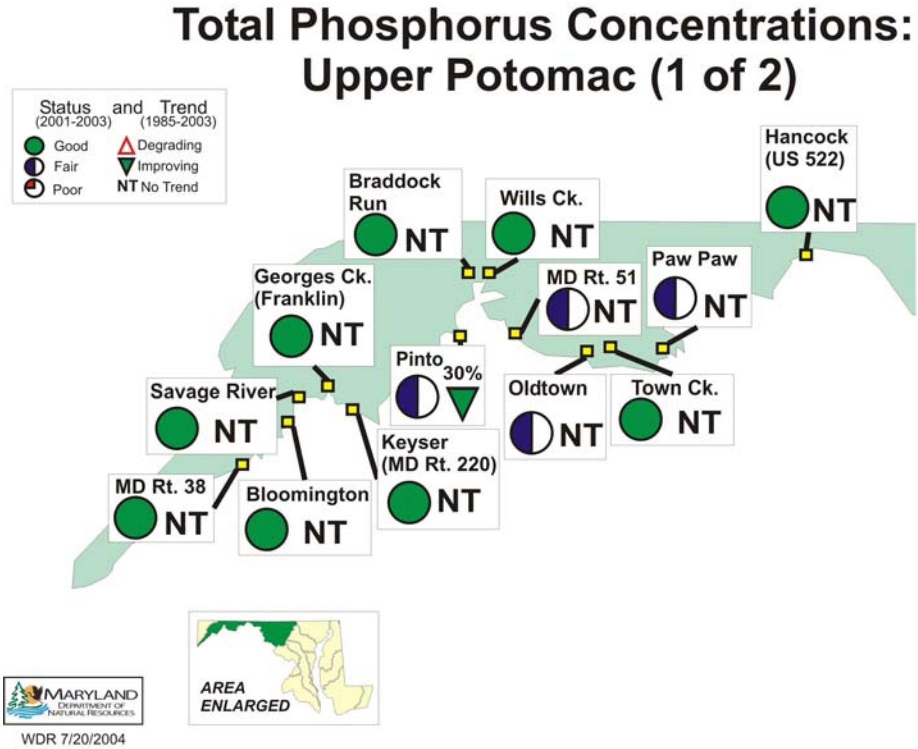


Figure UPR10 – Total Phosphorus Concentrations in the Upper Potomac River Basin (eastern)

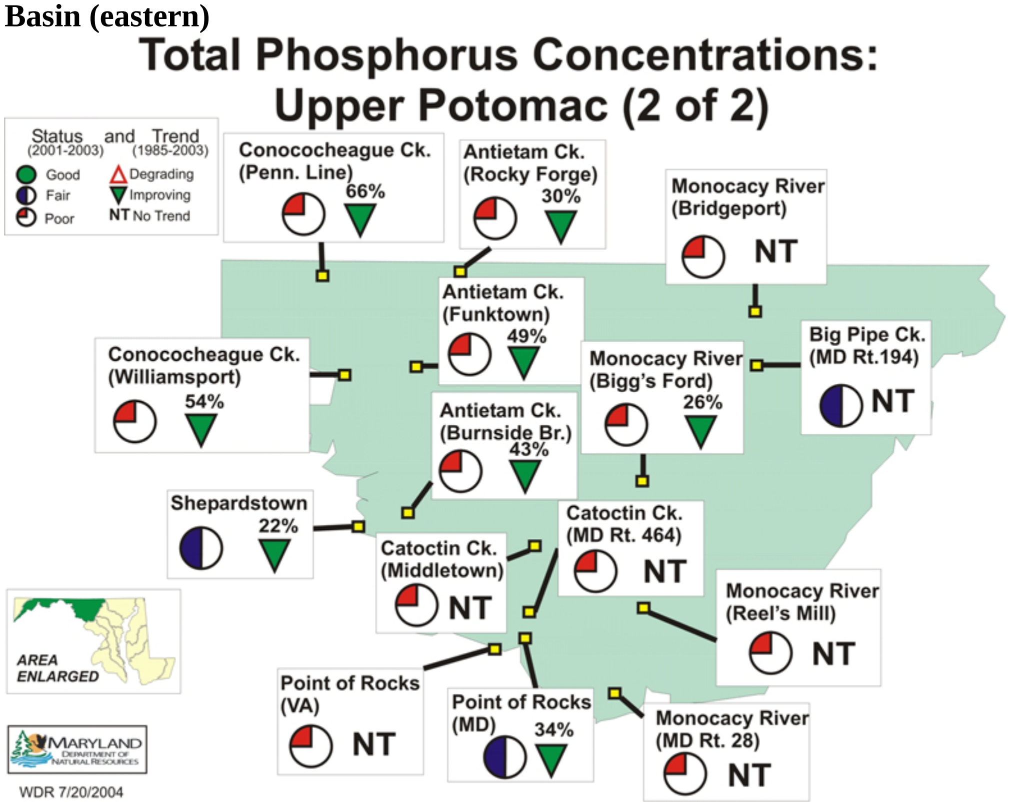


Figure UPR11 – Total Suspended Solids Concentrations in the Upper Potomac River Basin (western)

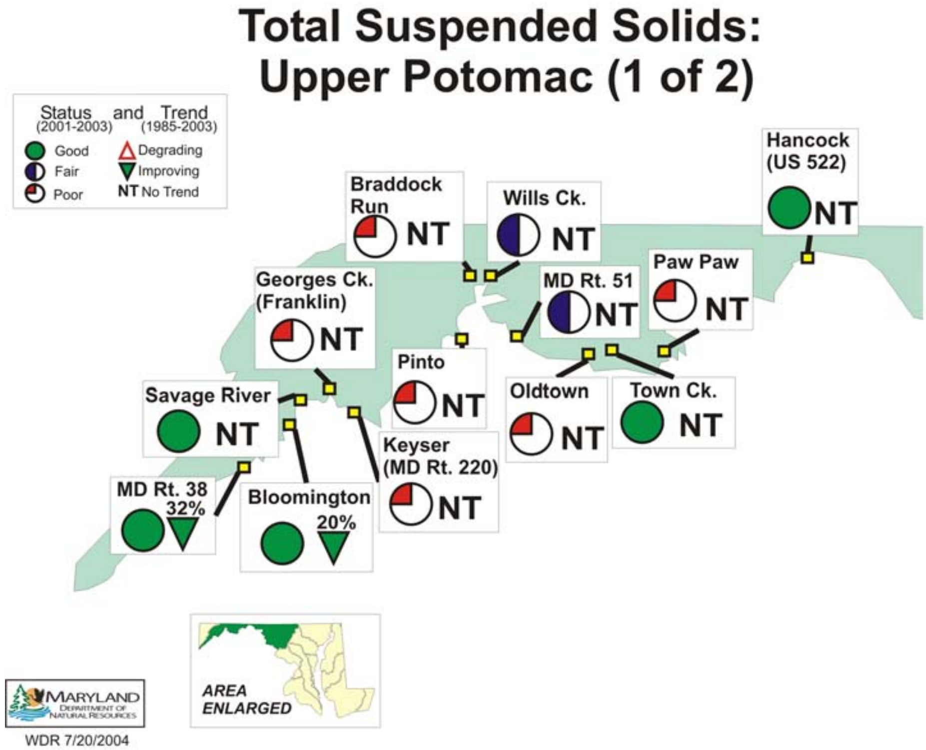
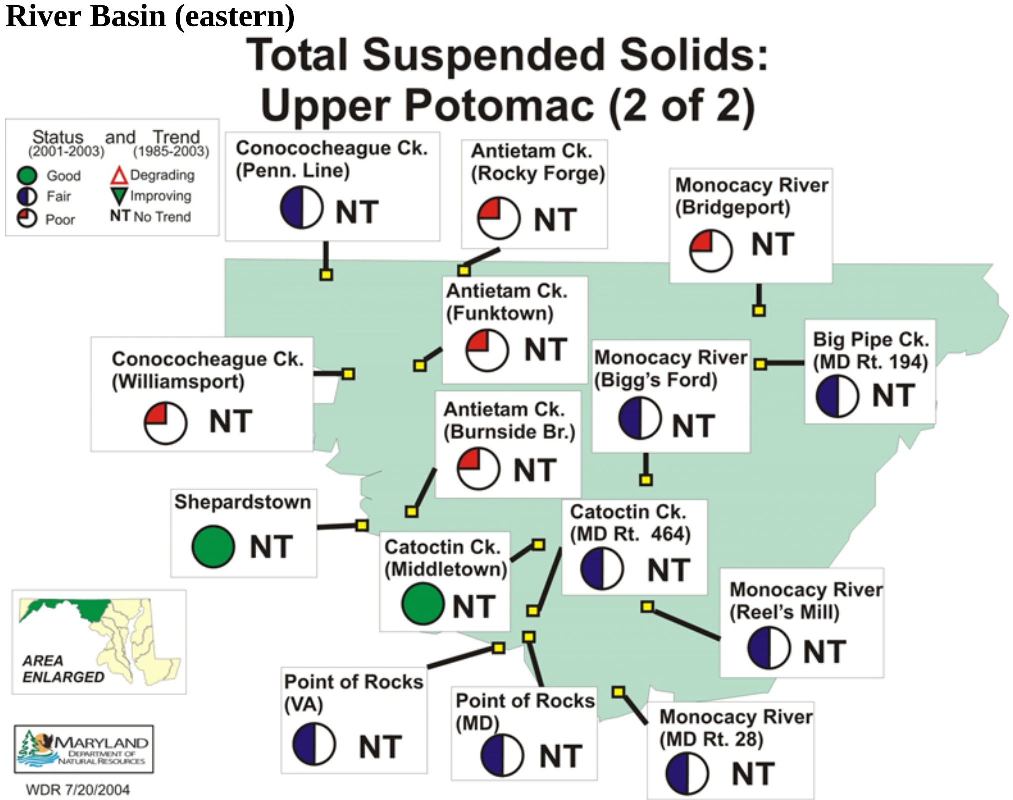
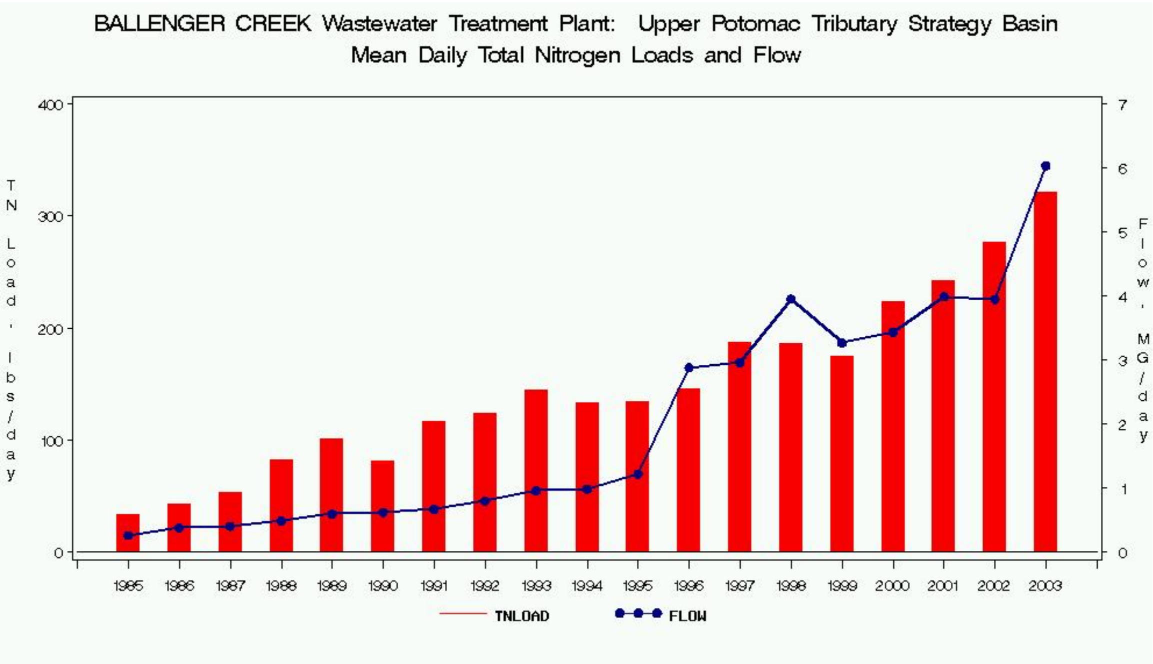
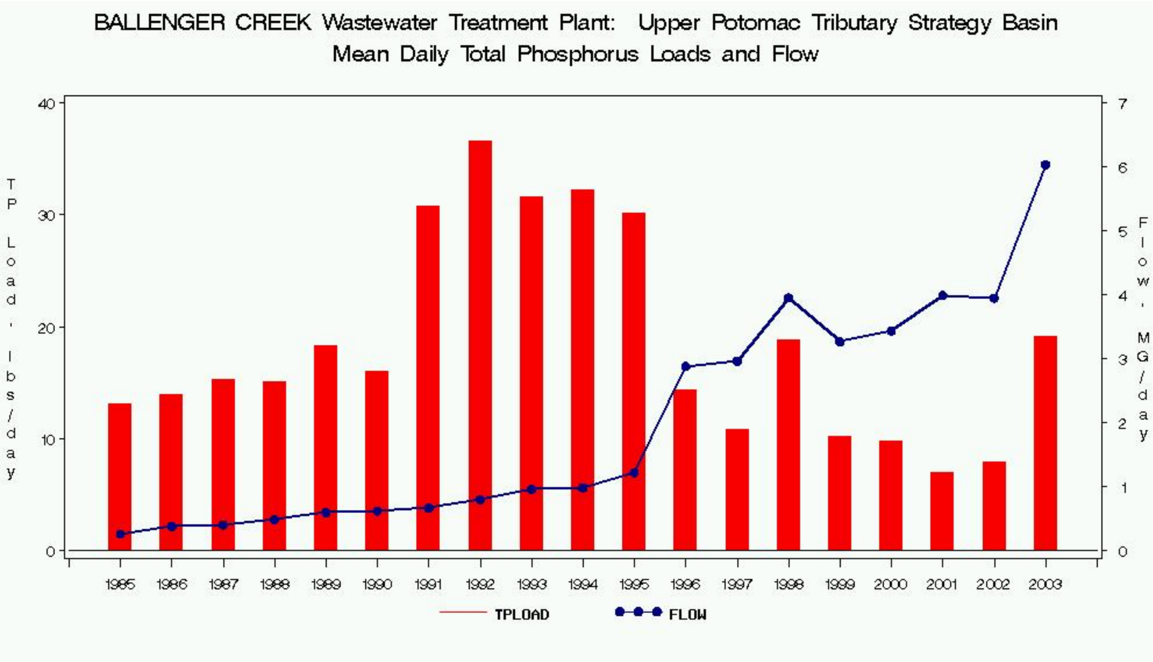


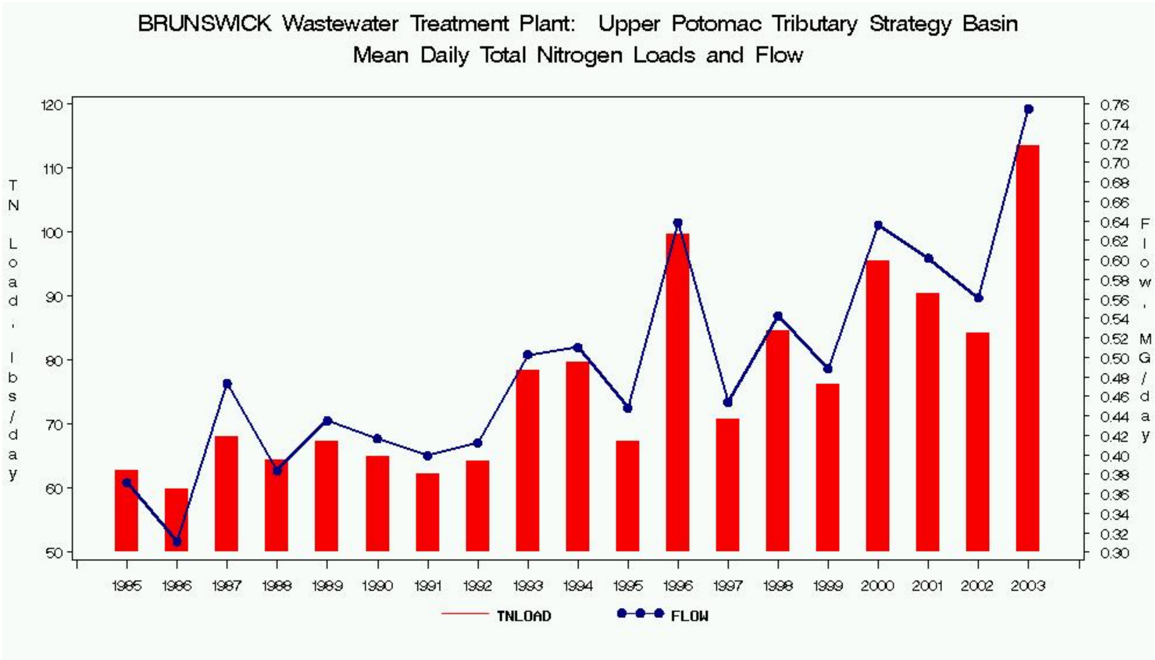
Figure UPR12 – Total Suspended Solids Concentrations in the Upper Potomac River Basin (eastern)

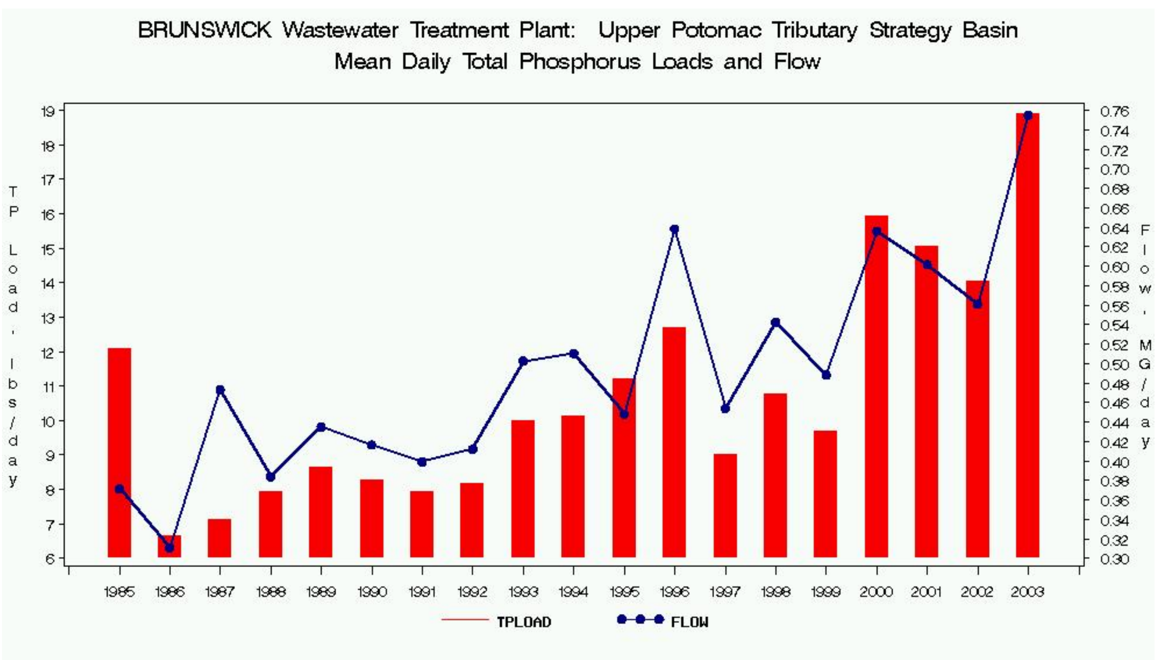


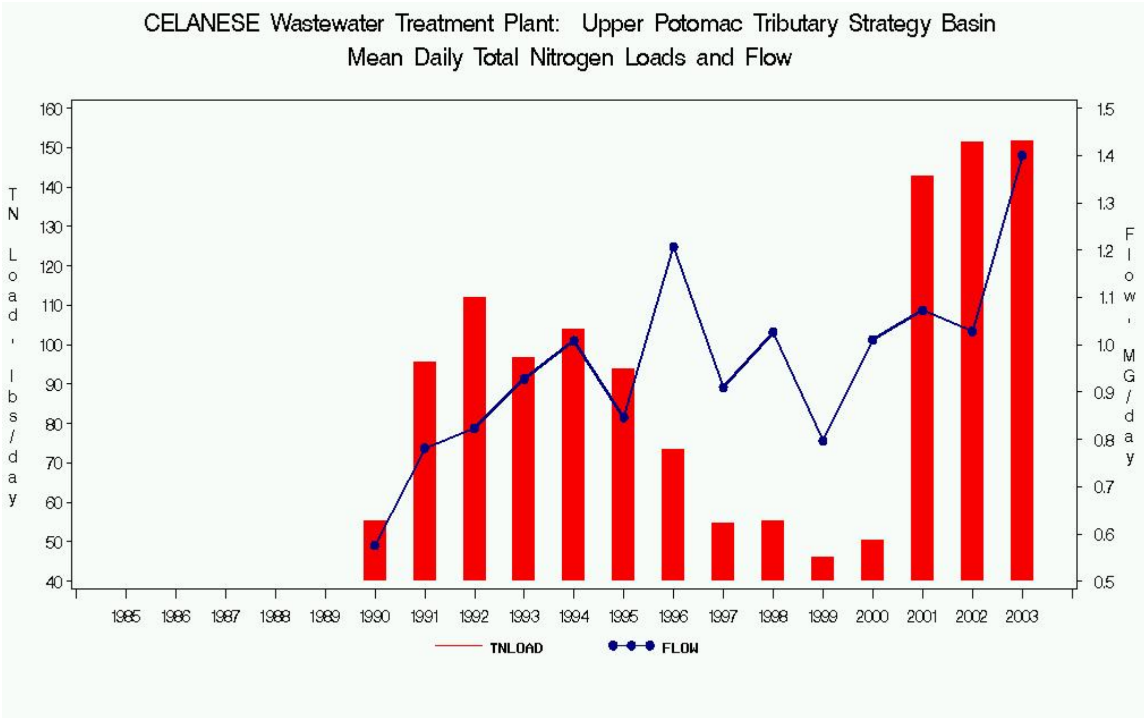
Appendix A – Nutrient Loadings from Major Wastewater Treatment Facilities in the Upper Potomac River Basin

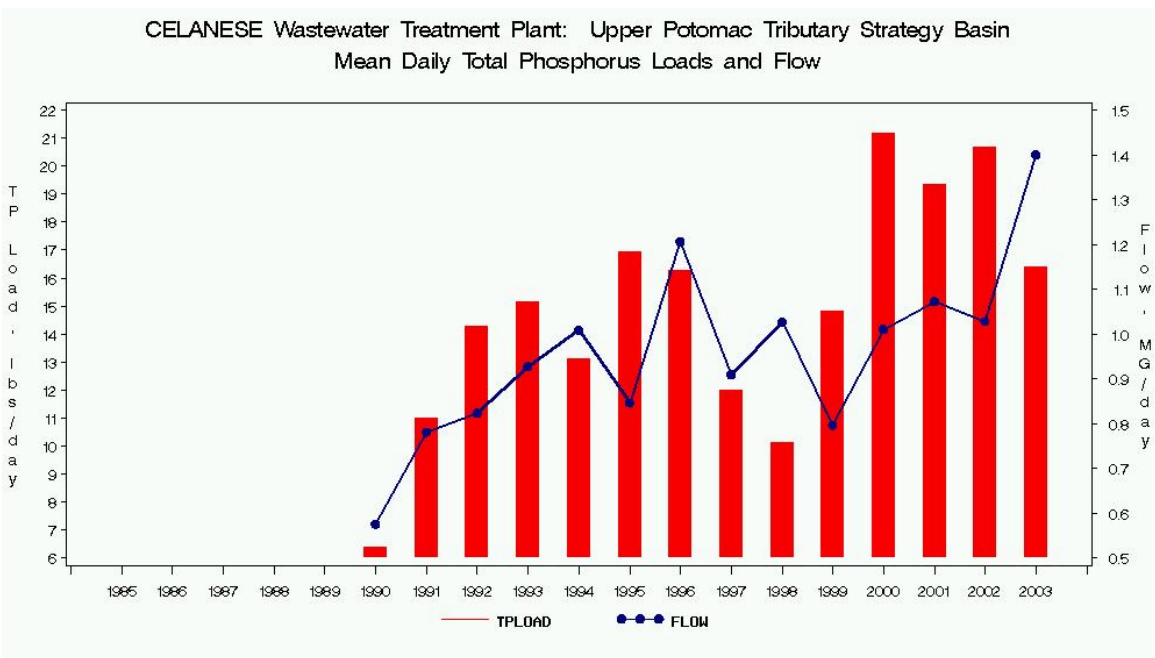


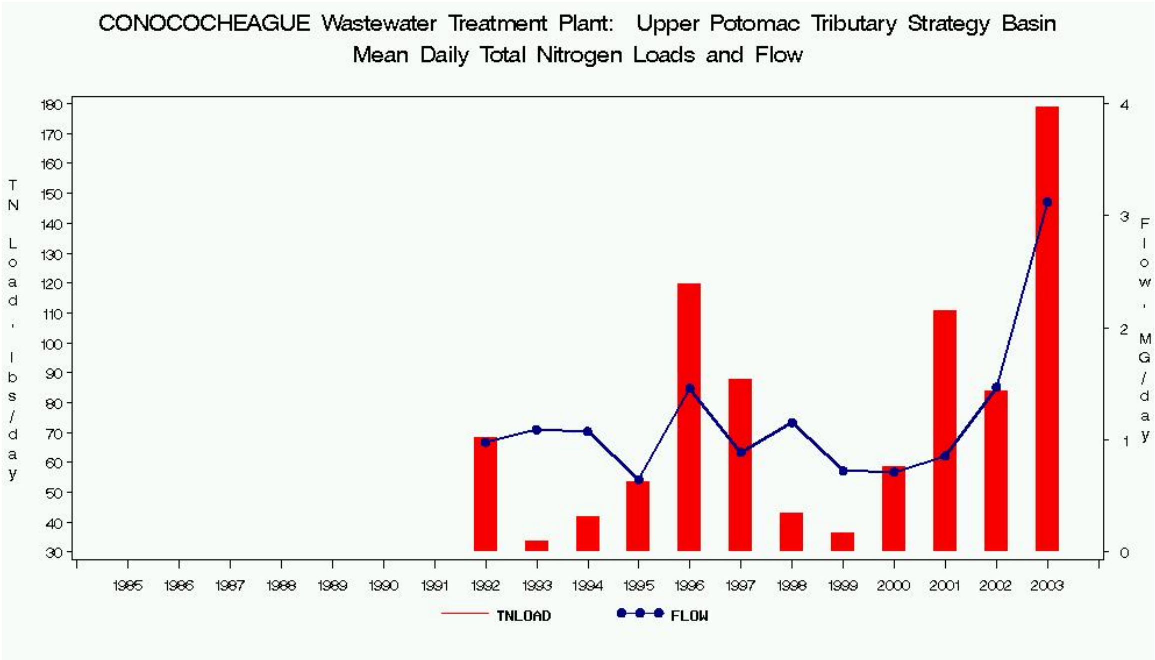


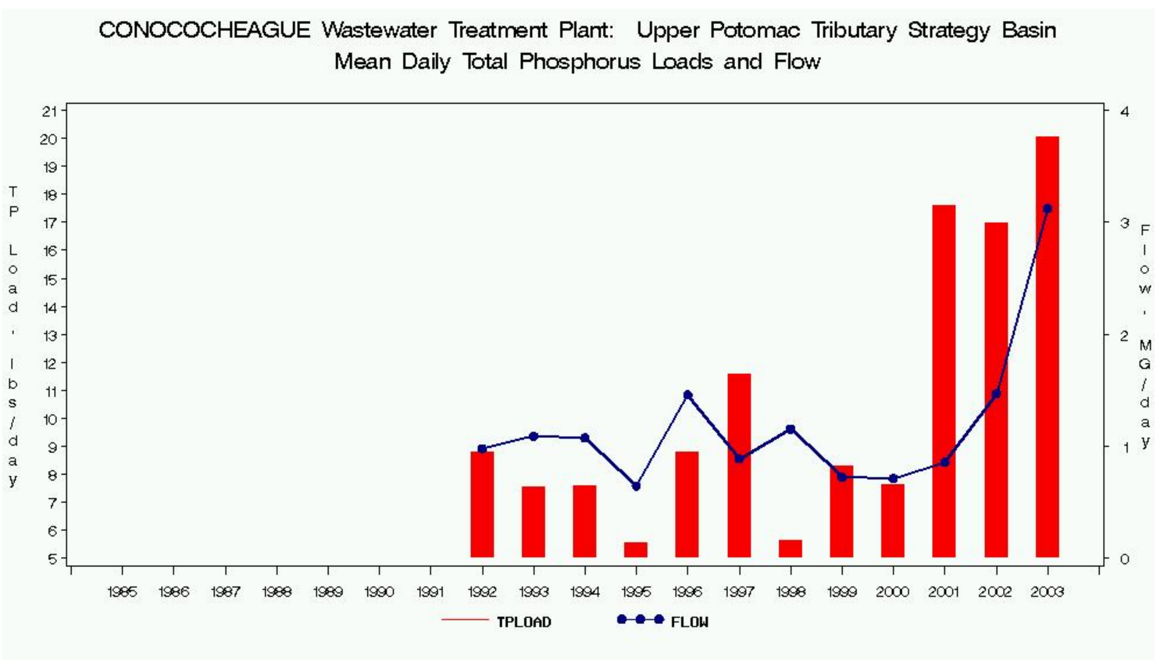

BRUNSWICK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
50
60
70
80
90
100
110
120
0.30
0.32
0.34
0.36
0.38
0.40
0.42
0.44
0.46
0.48
0.50
0.52
0.54
0.56
0.58
0.60
0.62
0.64
0.66
0.68
0.70
0.72
0.74
0.76
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TNLOAD
FLOW

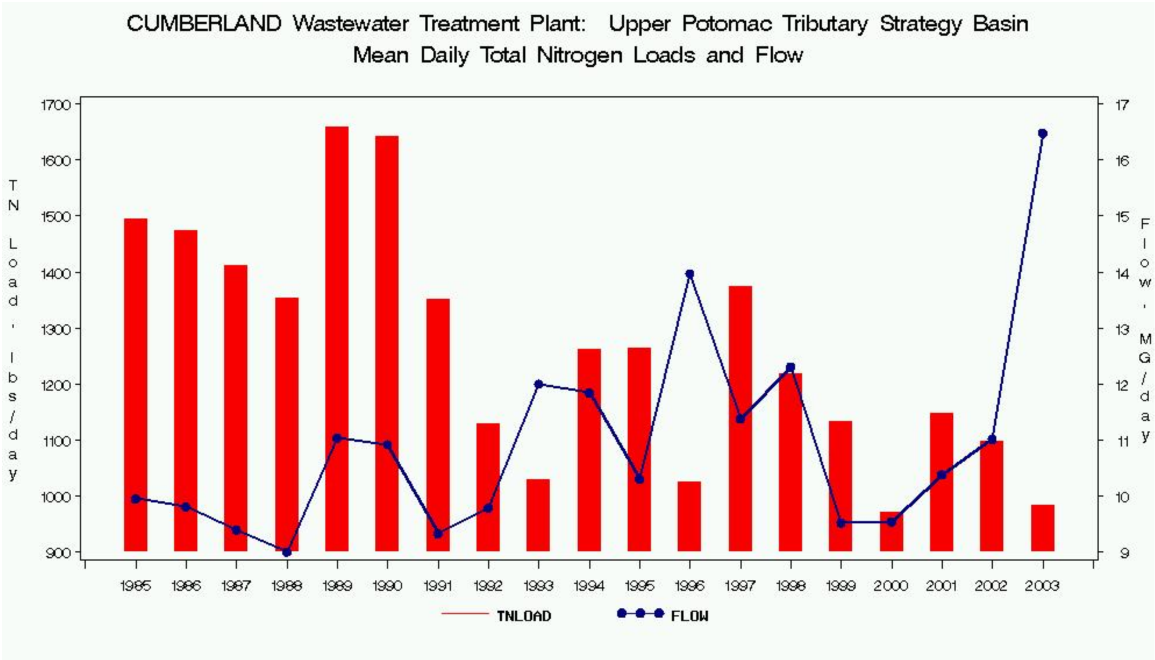

BRUNSWICK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
6
7
8
9
10
11
12
13
14
15
16
17
18
19
0.30
0.32
0.34
0.36
0.38
0.40
0.42
0.44
0.46
0.48
0.50
0.52
0.54
0.56
0.58
0.60
0.62
0.64
0.66
0.68
0.70
0.72
0.74
0.76
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TPLOAD
FLOW


CELANESE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW

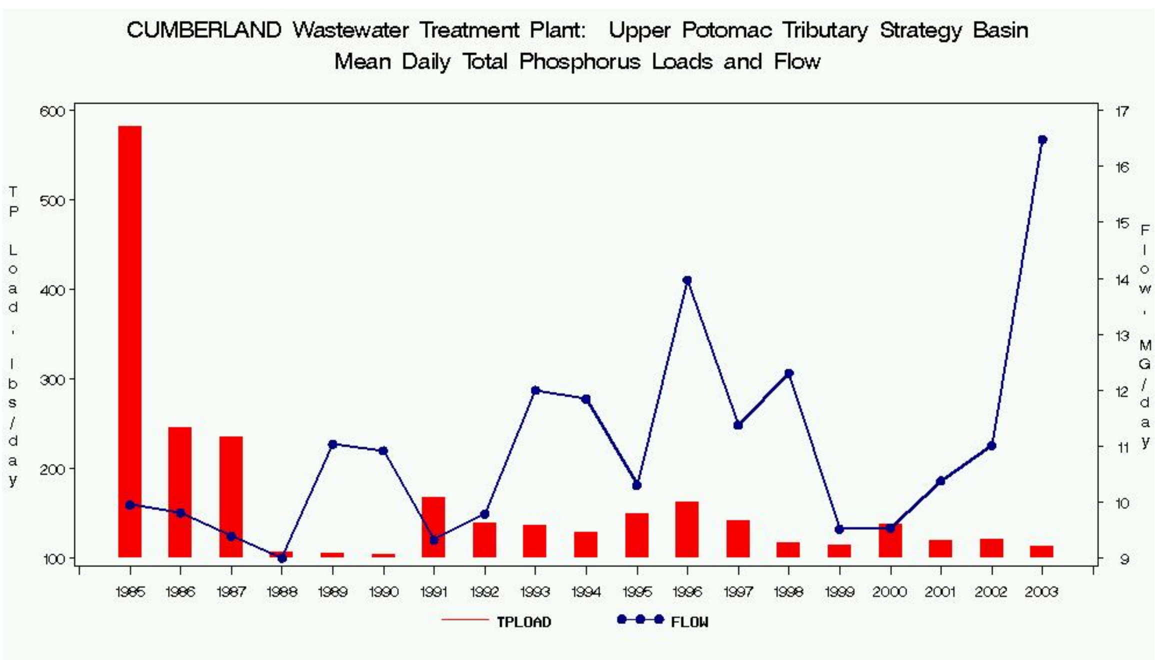

CELANESE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW


CONOCOCHEAGUE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TNLOAD
FLOW

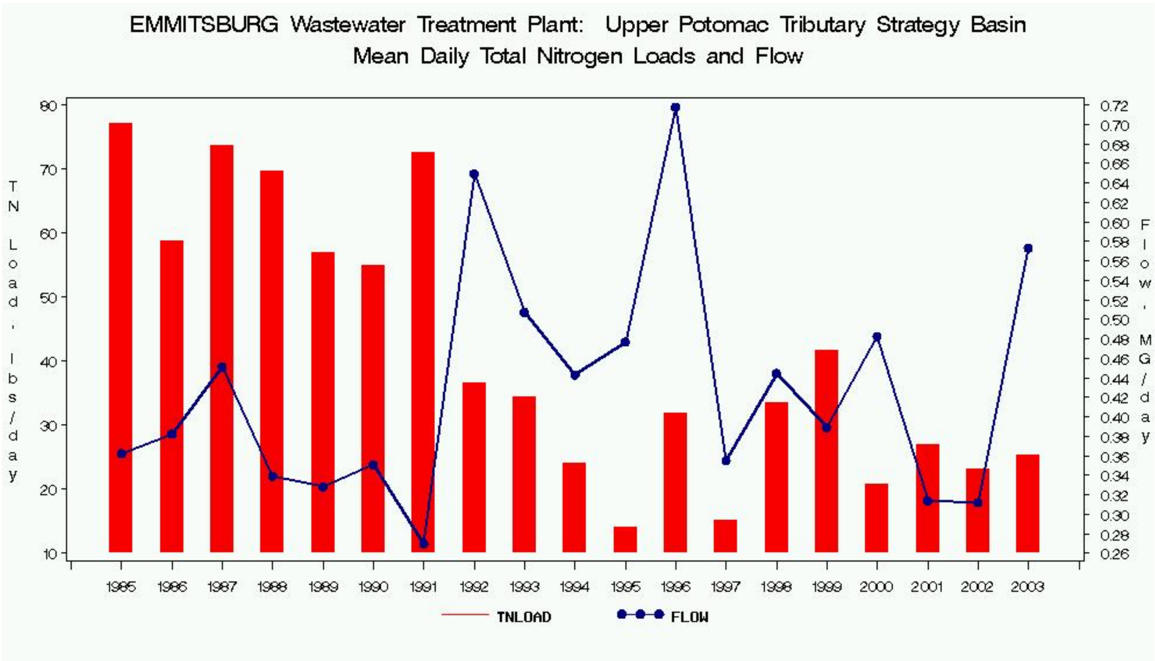

CONOCOCHEAGUE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TPLOAD
FLOW

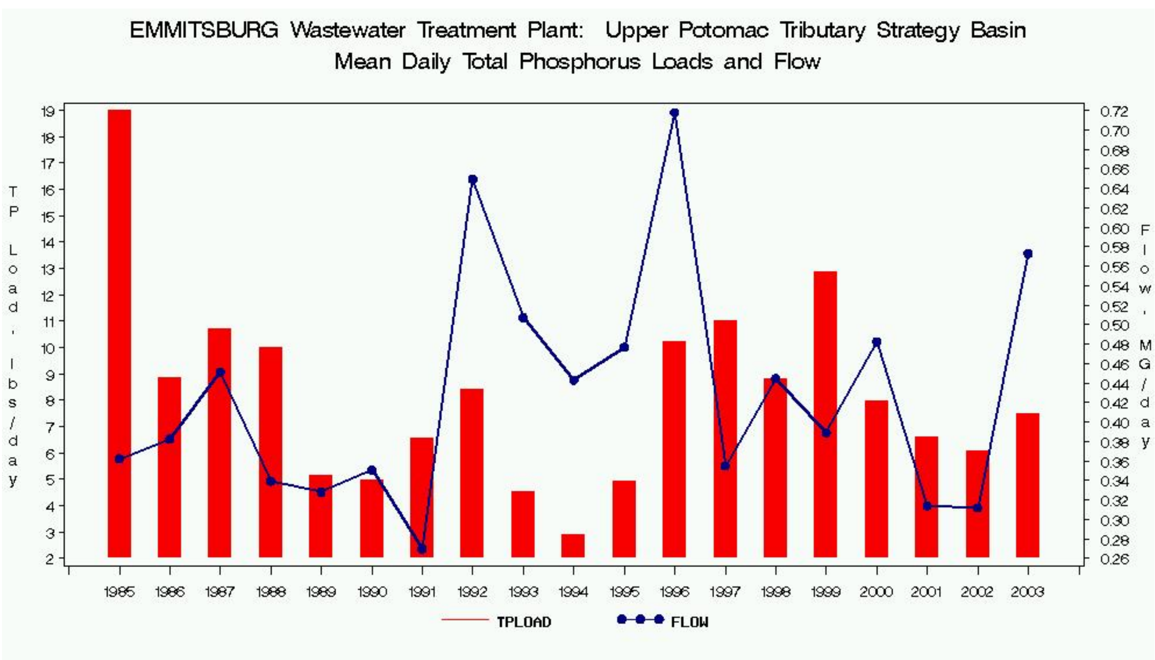


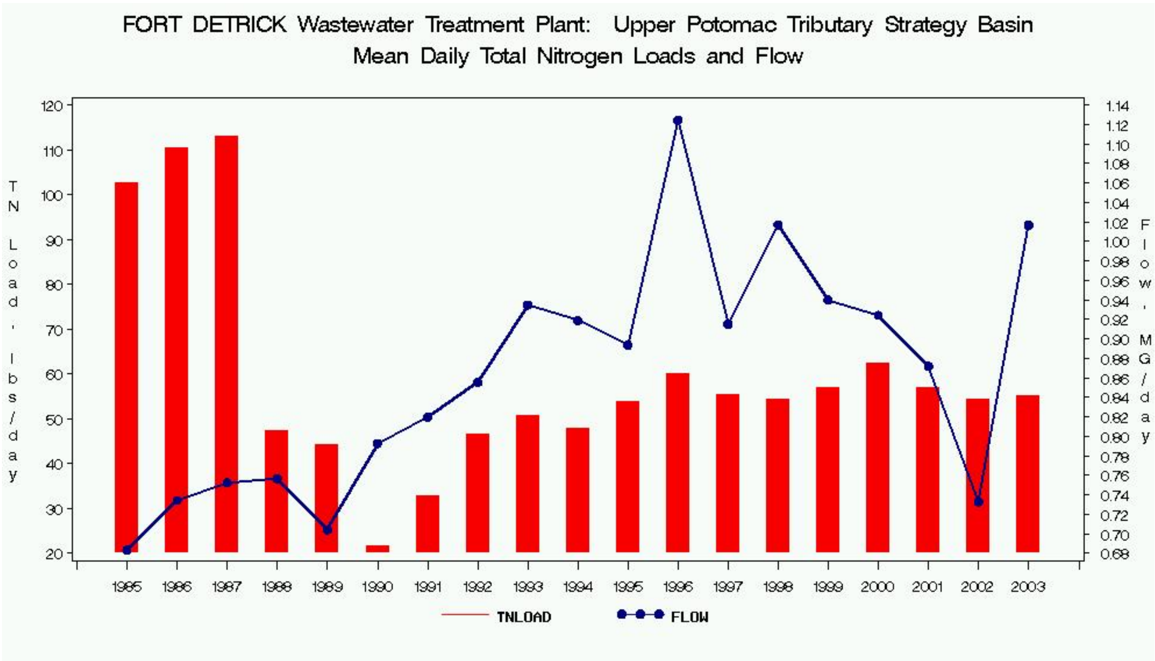
CUMBERLAND Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
1700
1600
1500
1400
1300
1200
1100
1000
900
17
16
15
14
13
12
11
10
9
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TNLOAD
FLOW

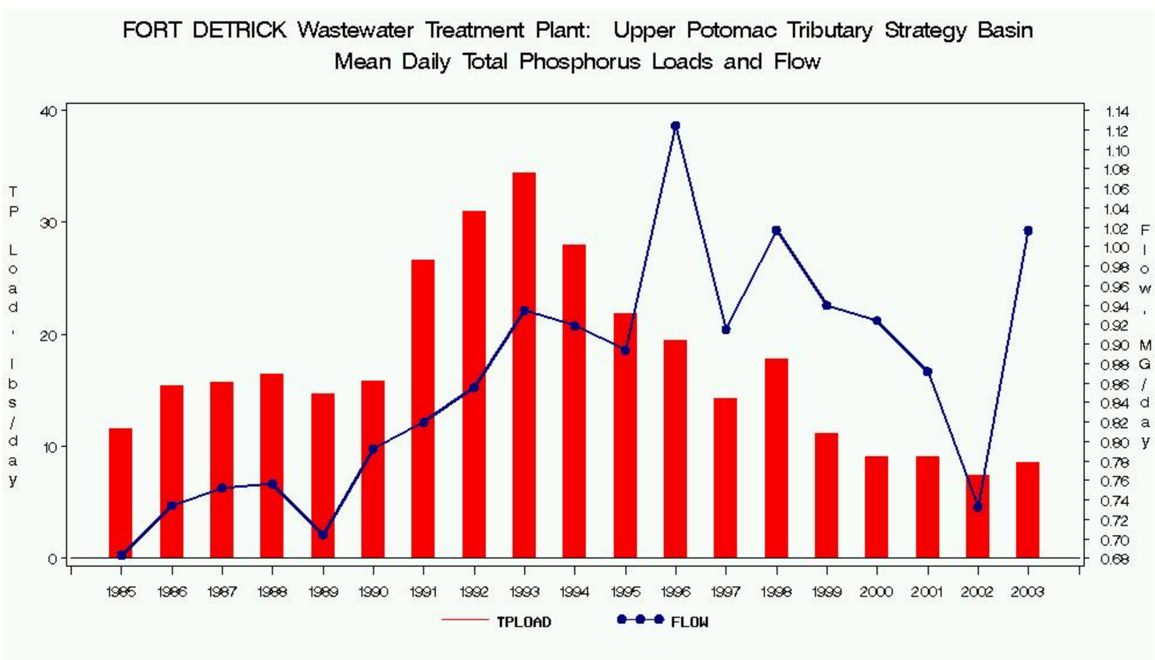


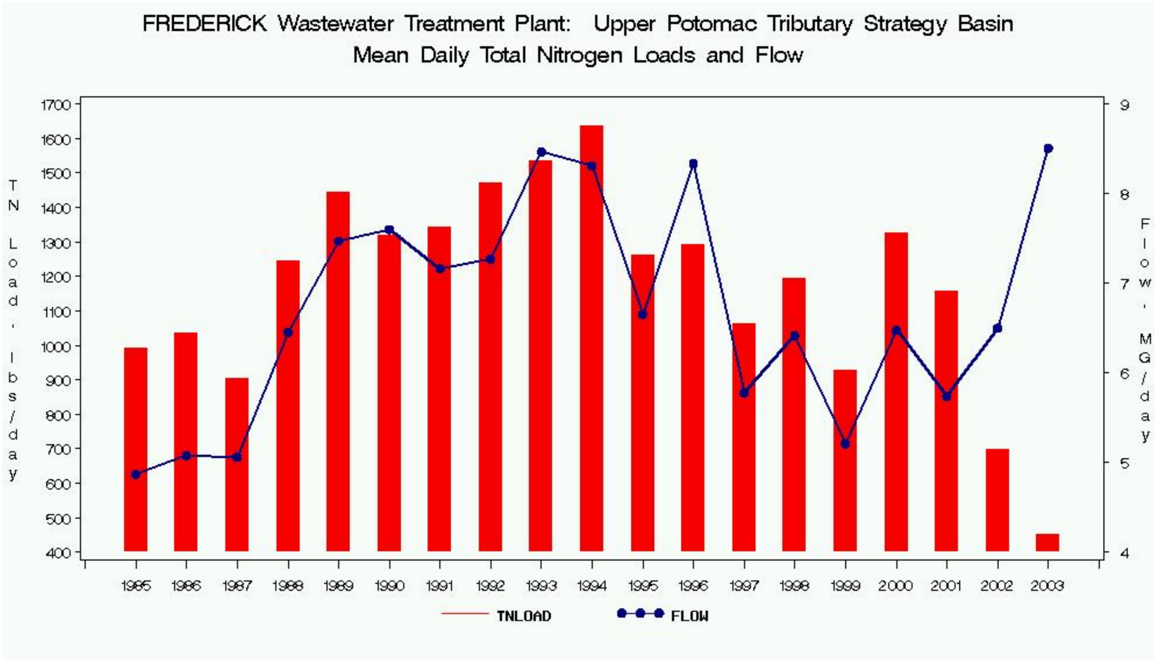
CUMBERLAND Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
600
500
400
300
200
100
17
16
15
14
13
12
11
10
9
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TPLOAD
FLOW

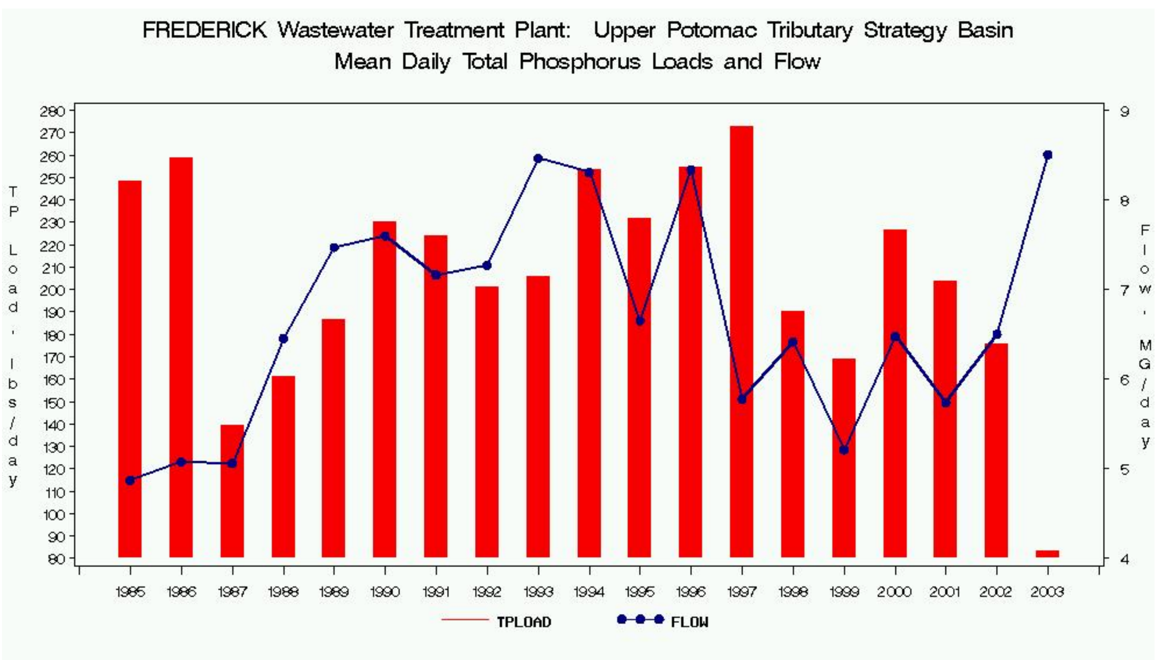

EMMITSBURG Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW

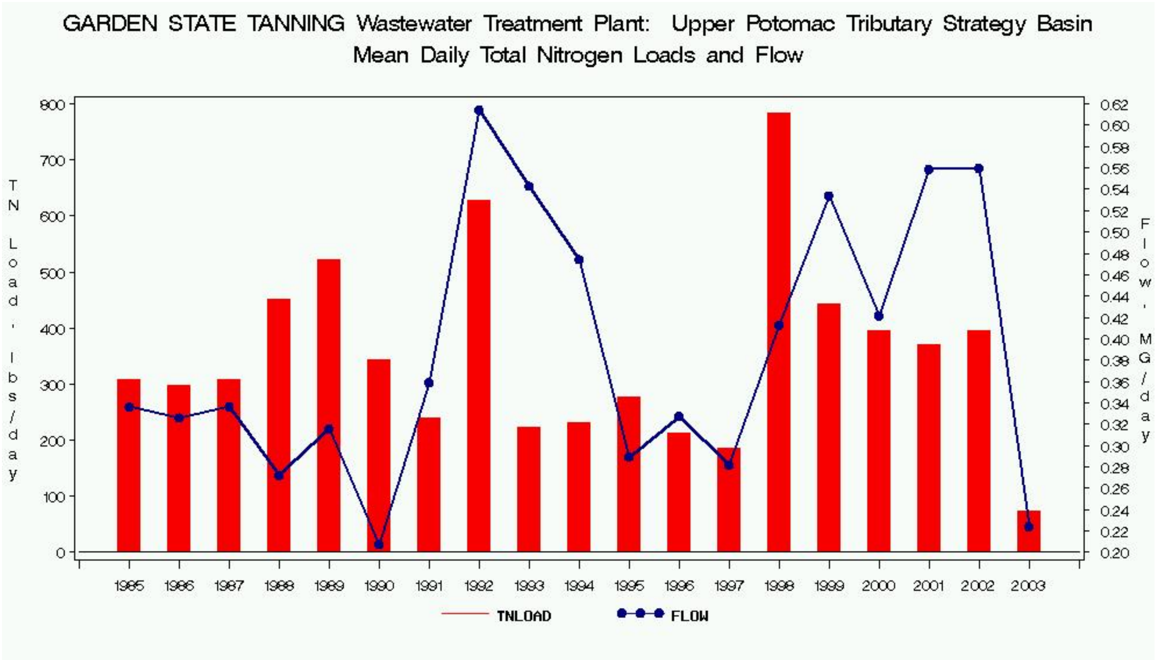

EMMITSBURG Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW

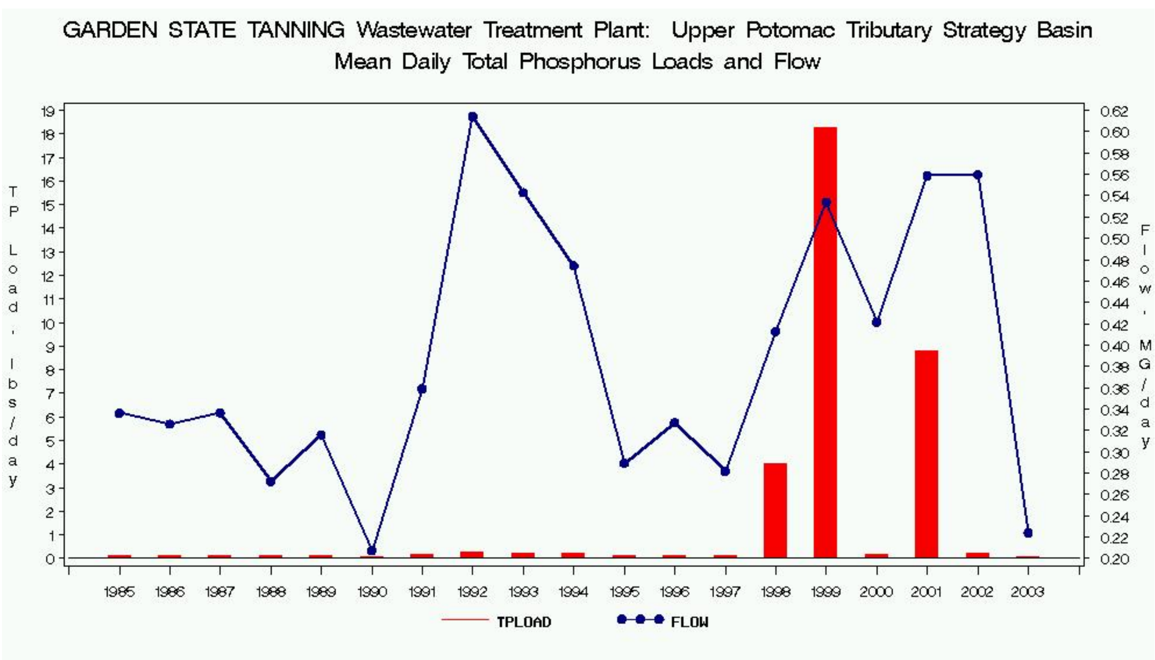

FORT DETRICK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TNLOAD
FLOW

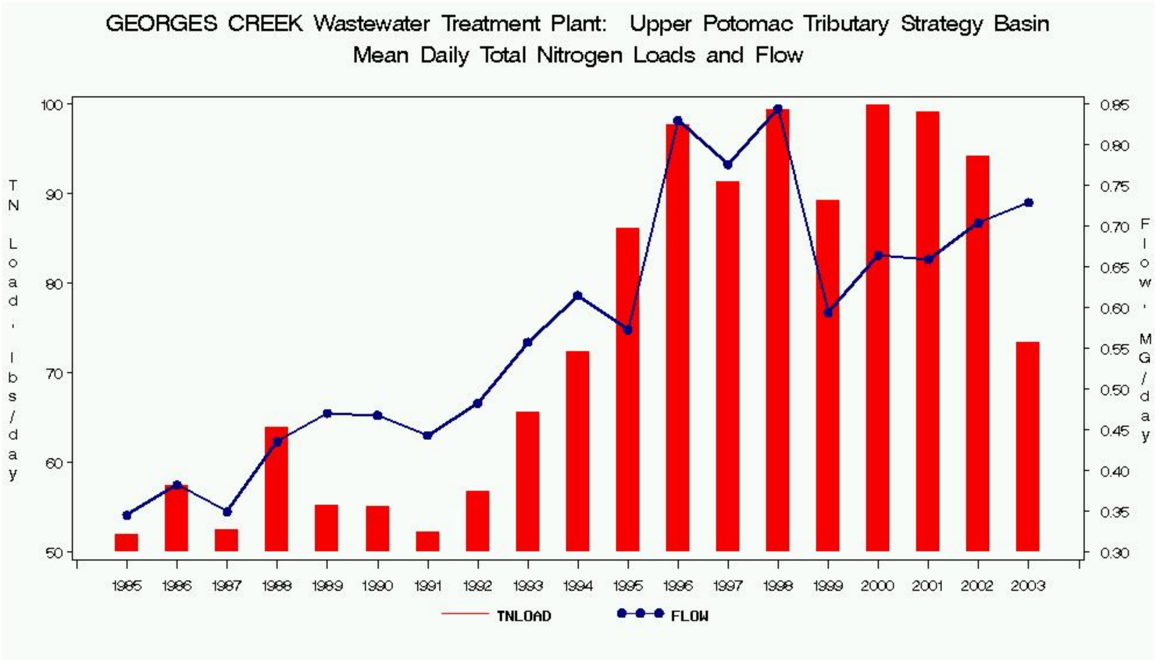

FORT DETRICK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TPLOAD
FLOW

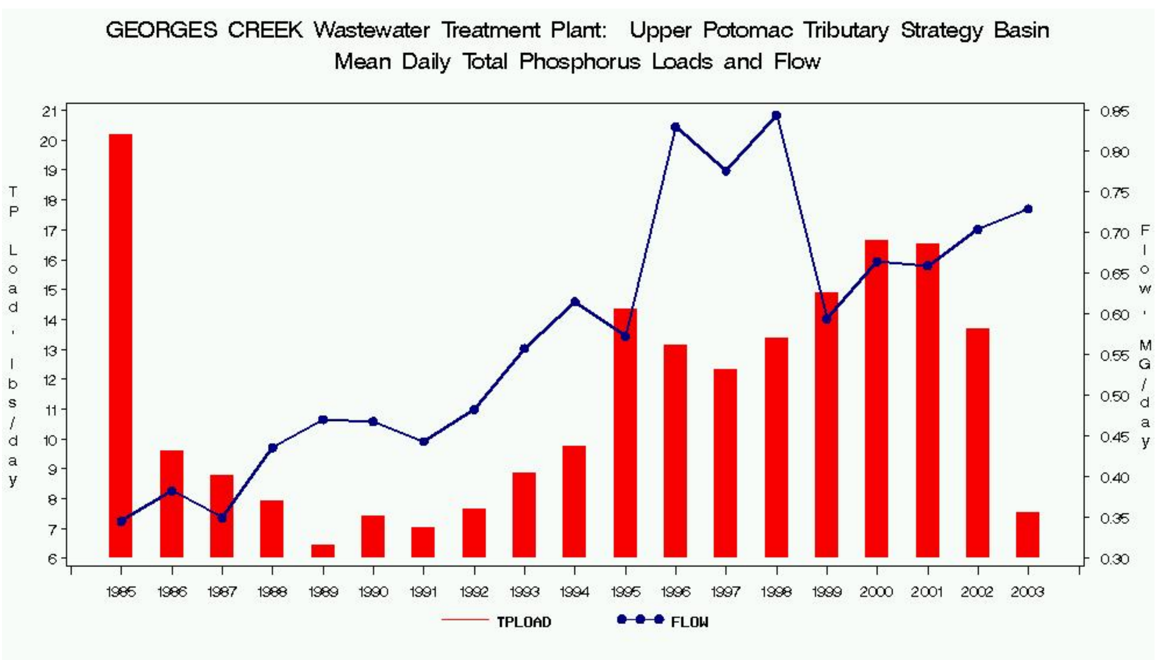

FREDERICK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TNLOAD
FLOW

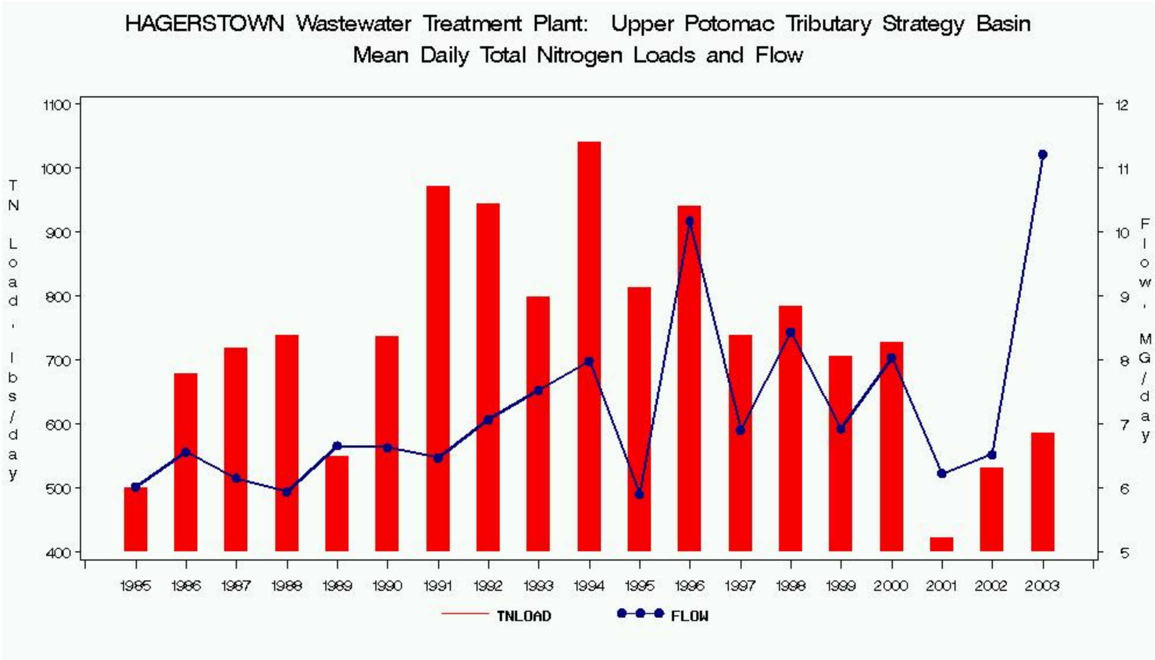

FREDERICK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TPLOAD
FLOW


GARDEN STATE TANNING Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW

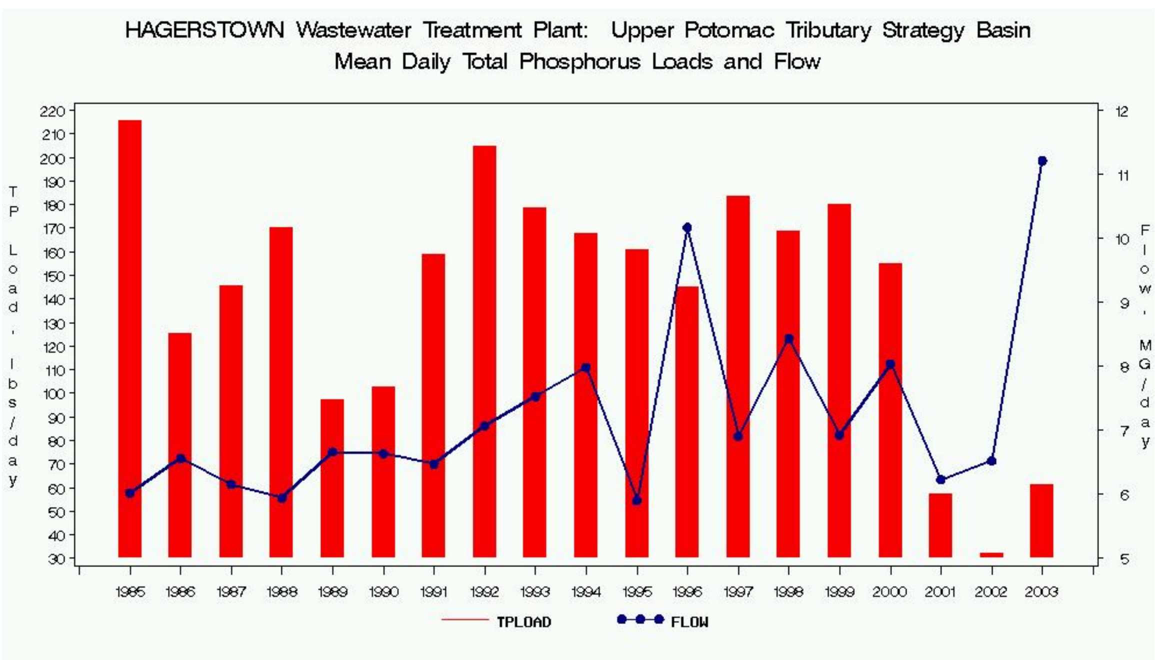

GARDEN STATE TANNING Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW


GEORGES CREEK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW


GEORGES CREEK Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW

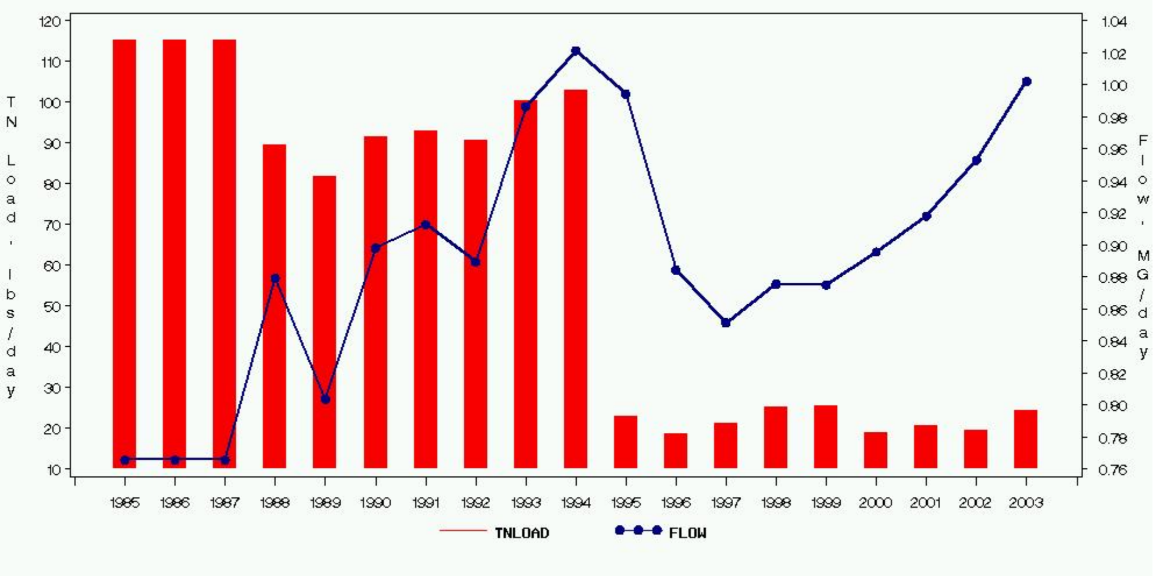


HAGERSTOWN Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
400
500
600
700
800
900
1000
1100
5
6
7
8
9
10
11
12
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TNLOAD
FLOW

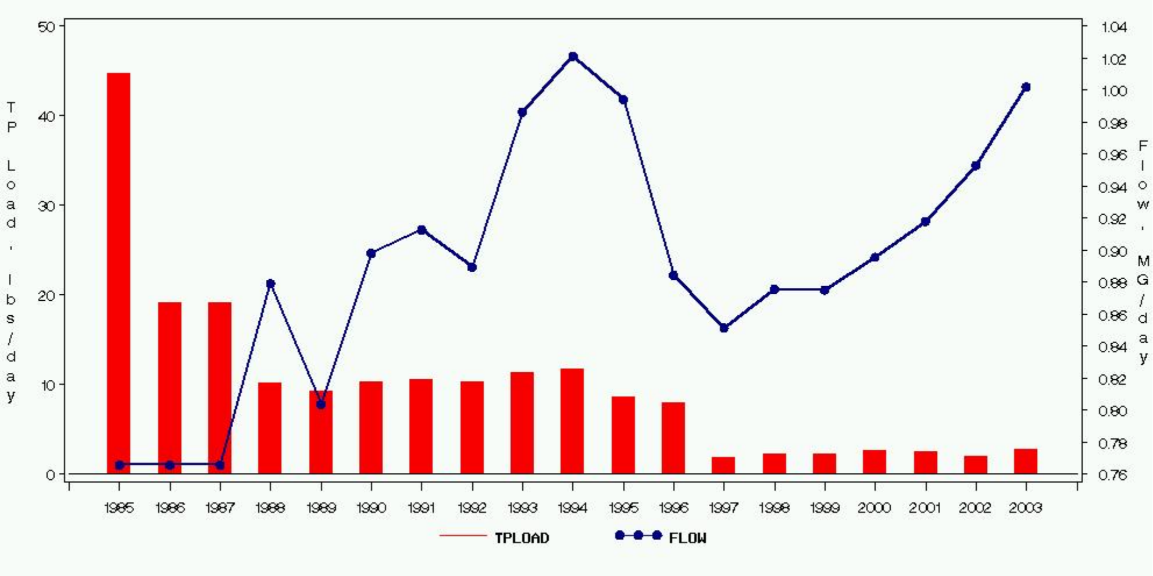


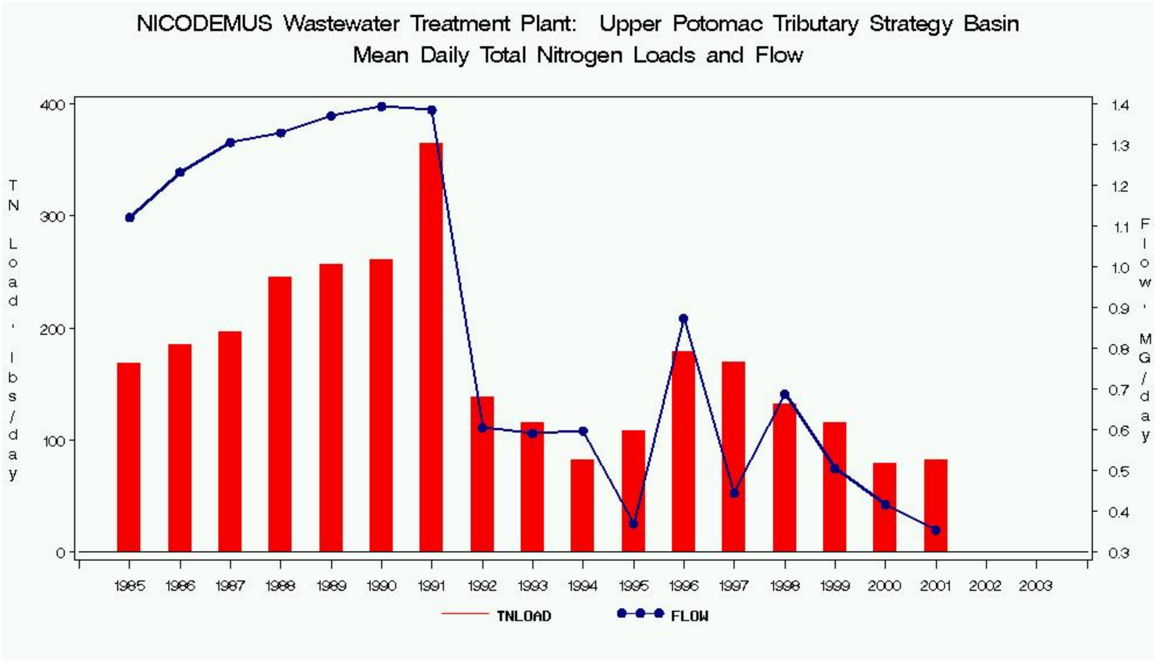
HAGERSTOWN Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
5
6
7
8
9
10
11
12
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TPLOAD
FLOW

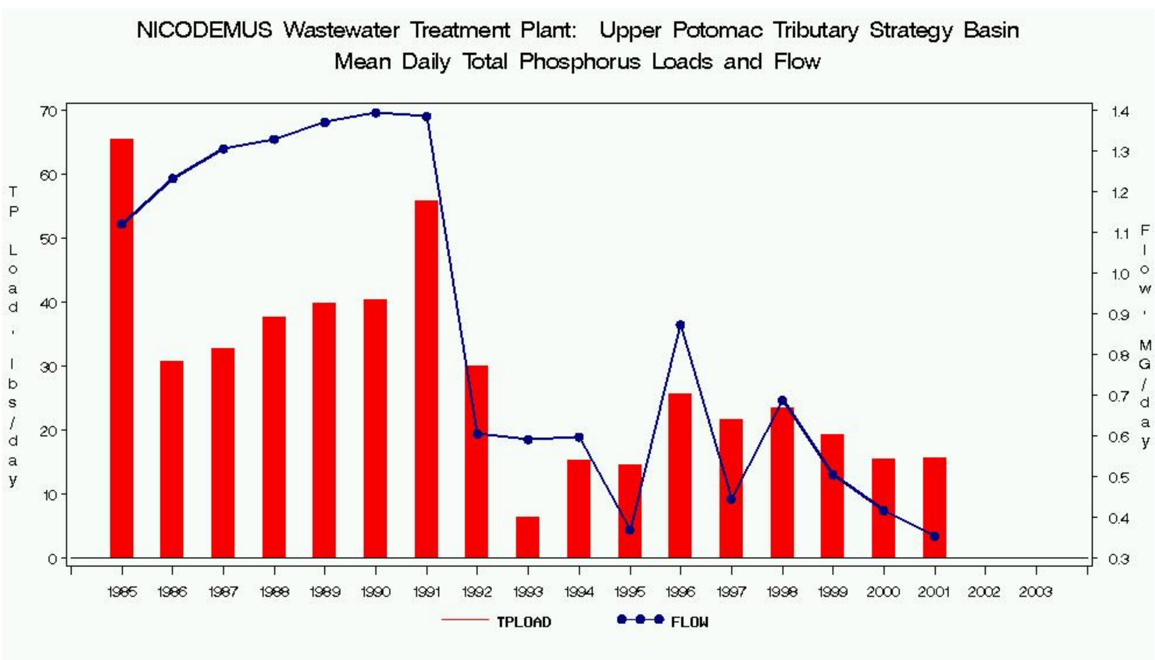
MARYLAND CORRECTIONAL INSTITUTE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow

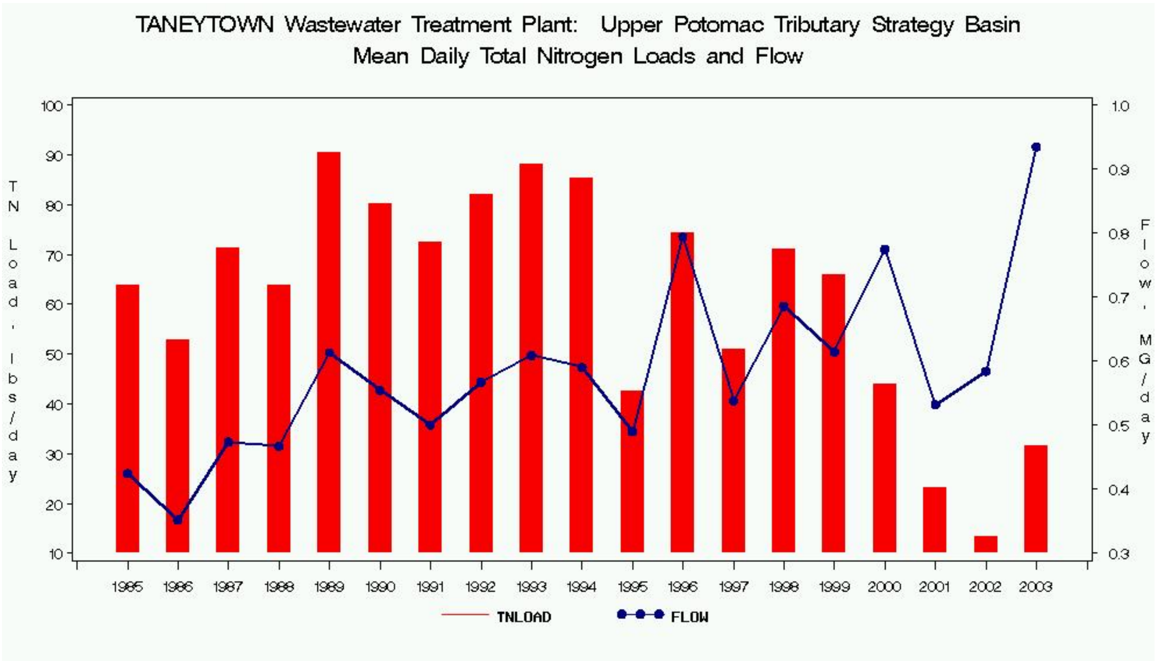


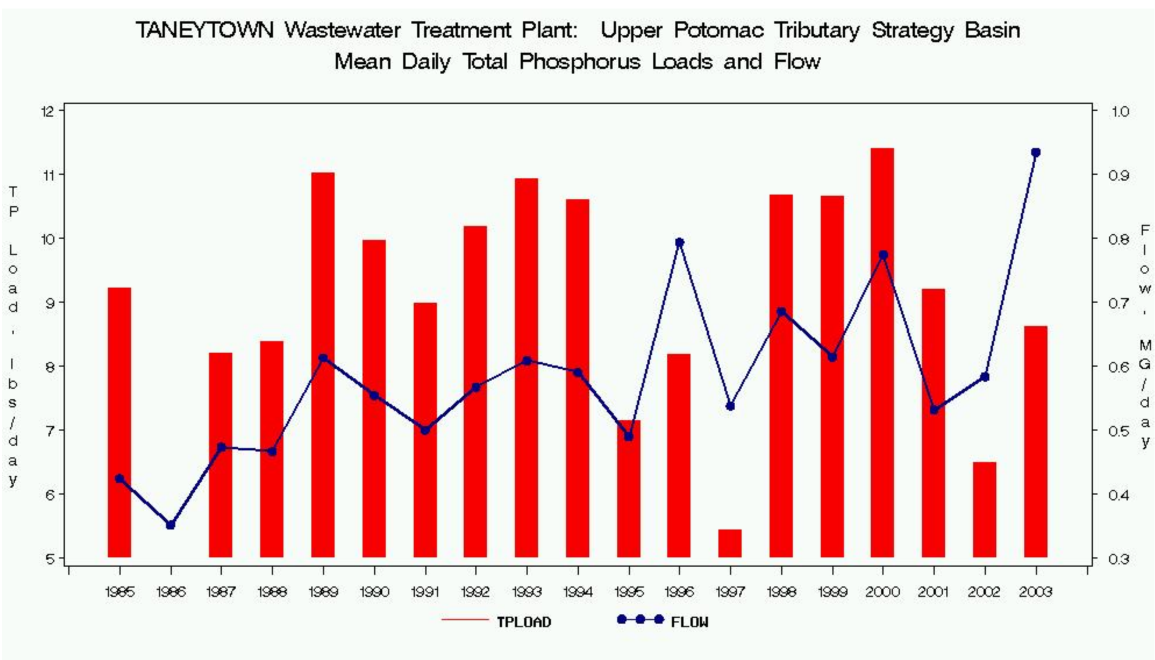
MARYLAND CORRECTIONAL INSTITUTE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow

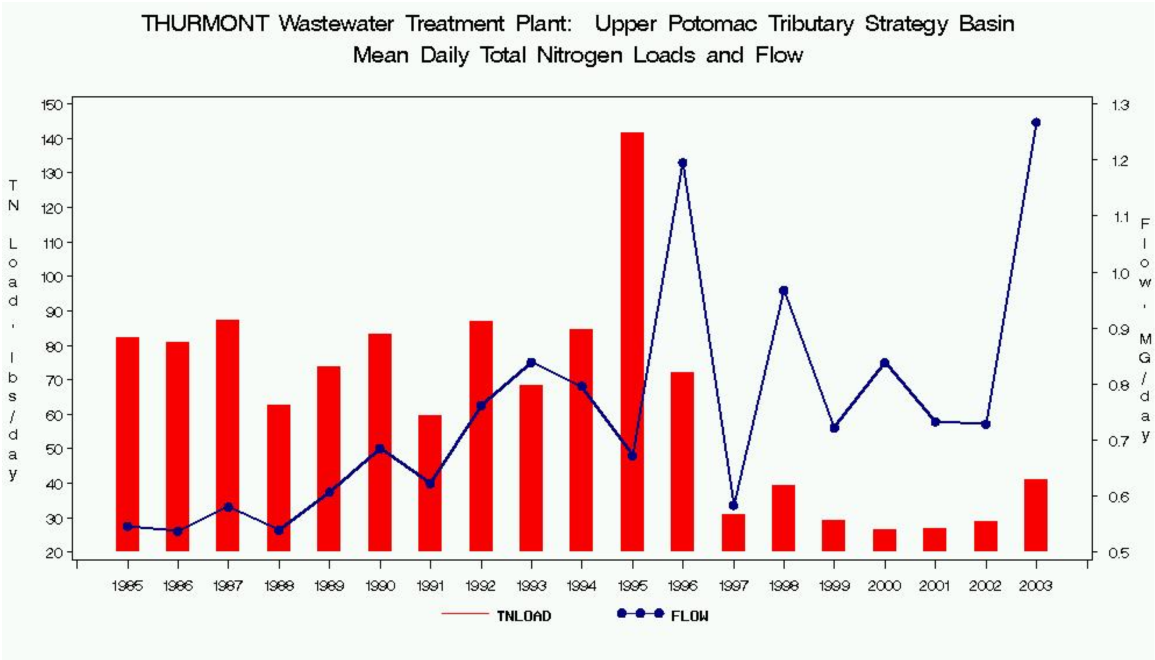



NICODEMUS Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW

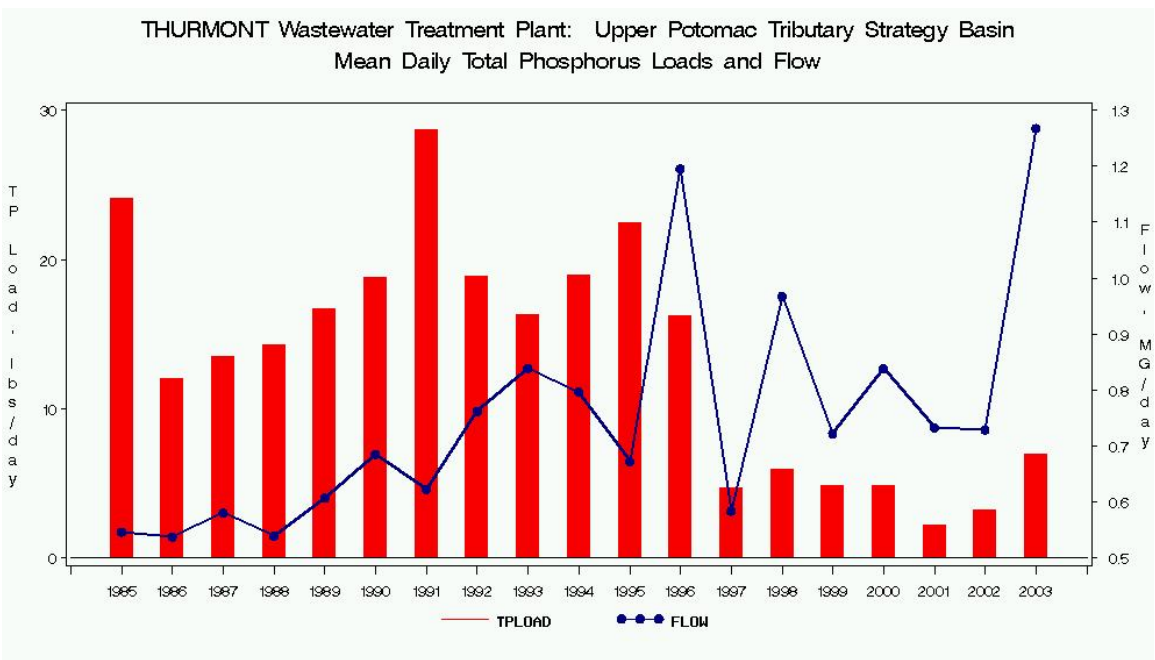

NICODEMUS Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW


TANEYTOWN Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW


TANEYTOWN Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW

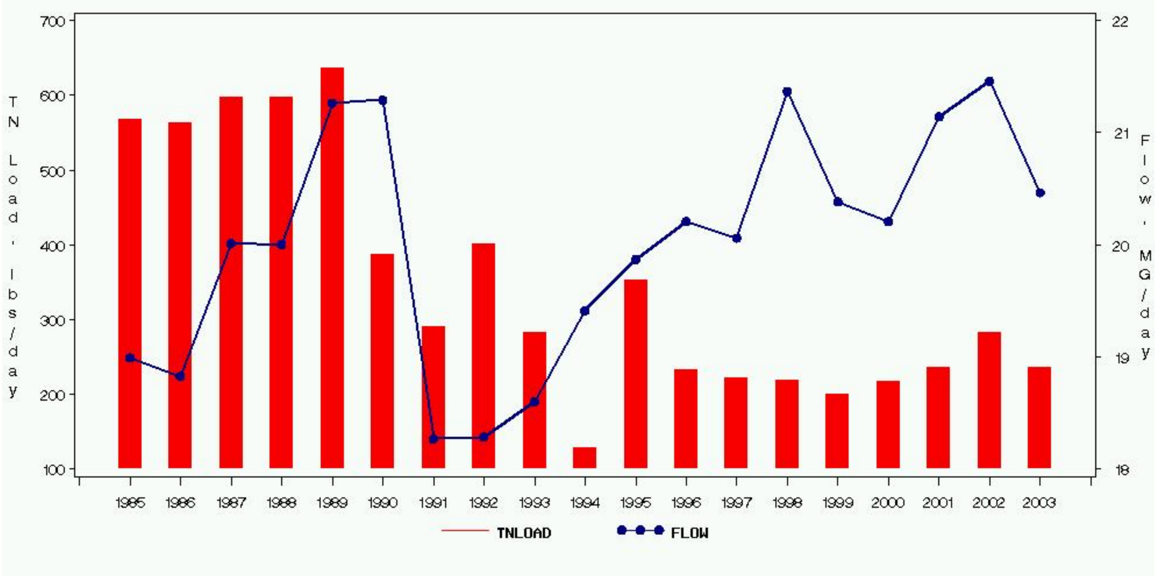


THURMONT Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
150
140
130
120
110
100
90
80
70
60
50
40
30
20
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TNLOAD
FLOW

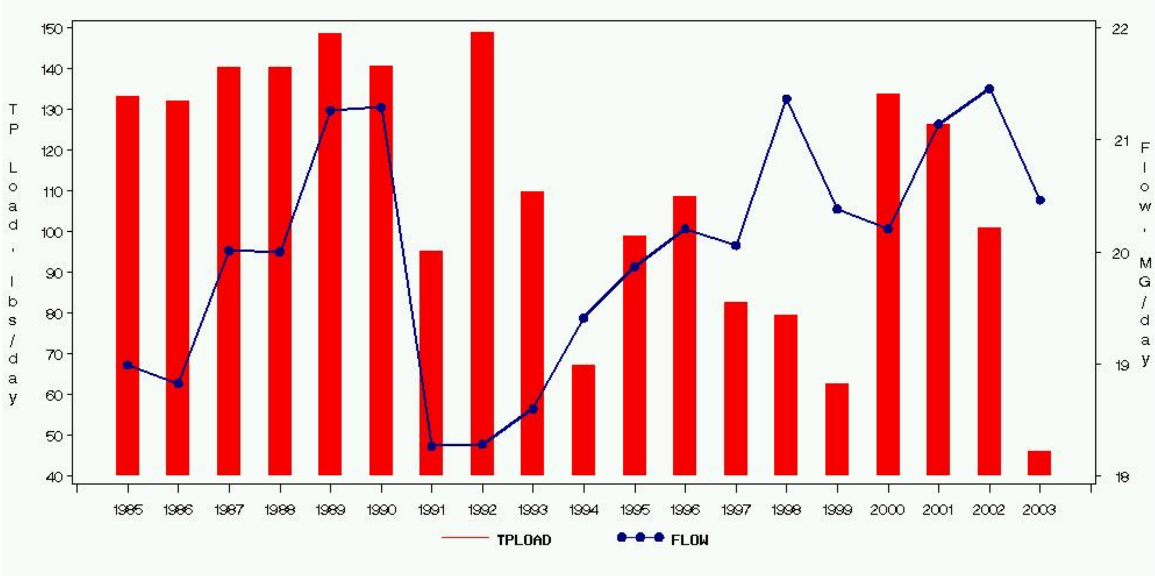


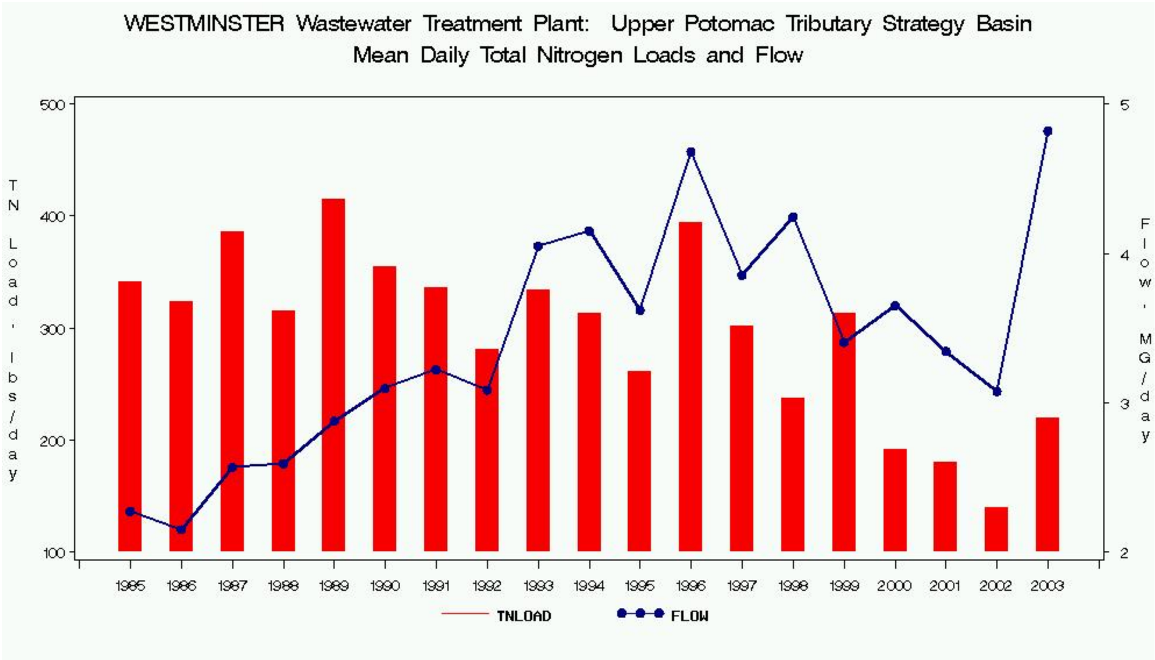
THURMONT Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
30
20
10
0
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
TPLOAD
FLOW

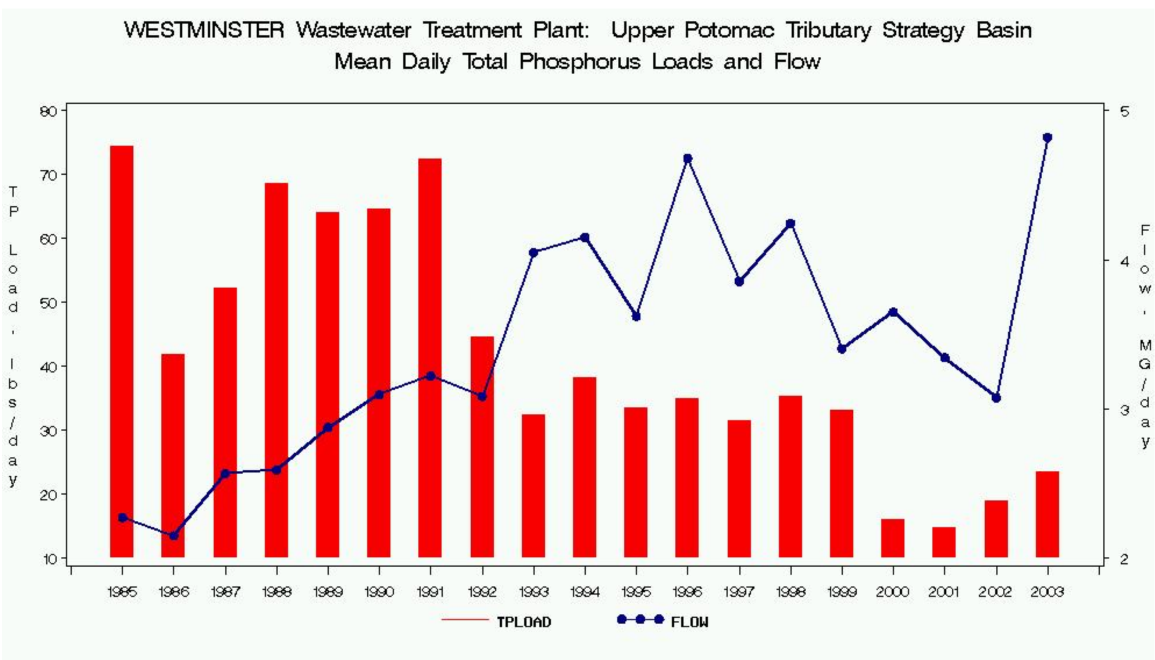
UPPER POTOMAC RIVER COMMISSION Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow

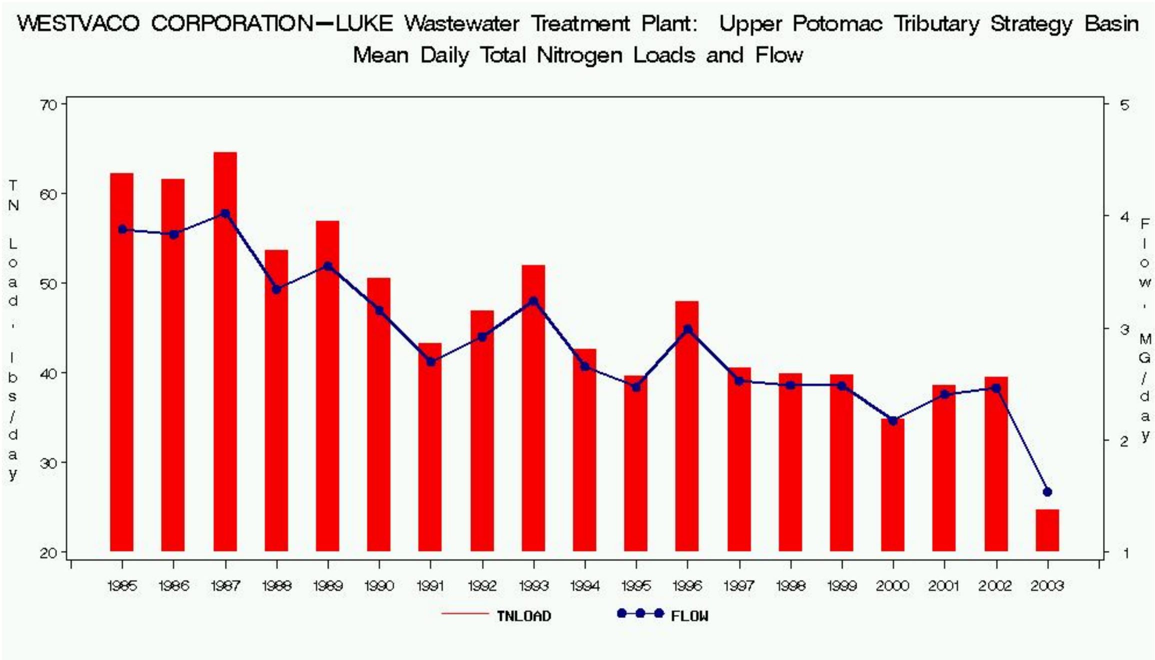


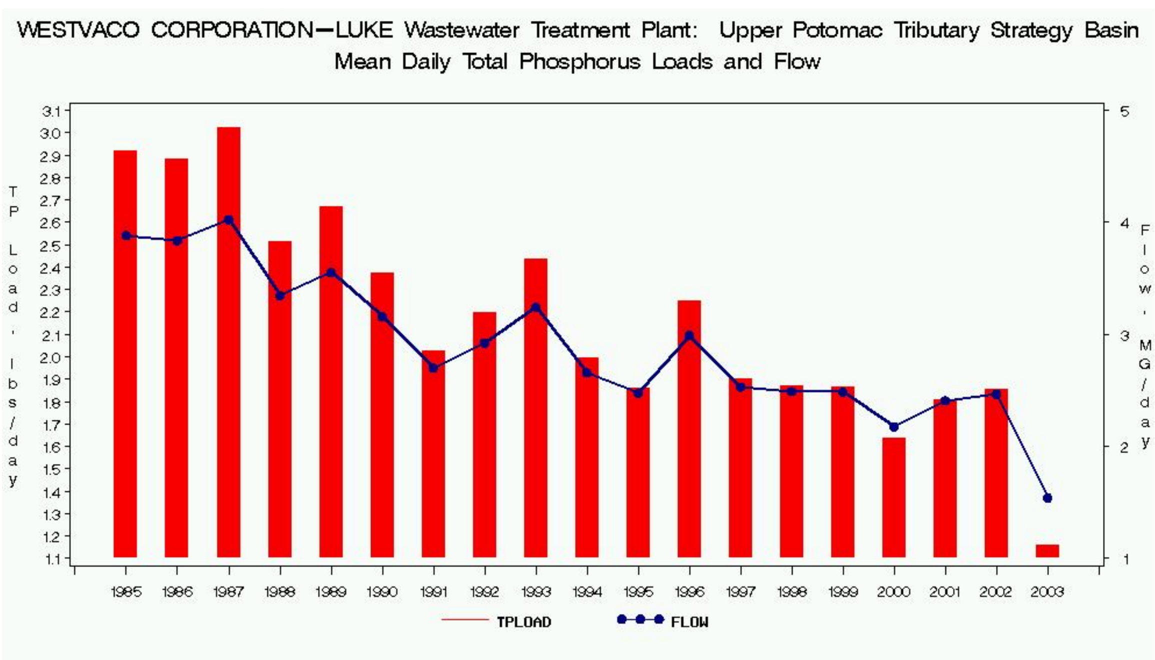
UPPER POTOMAC RIVER COMMISSION Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow

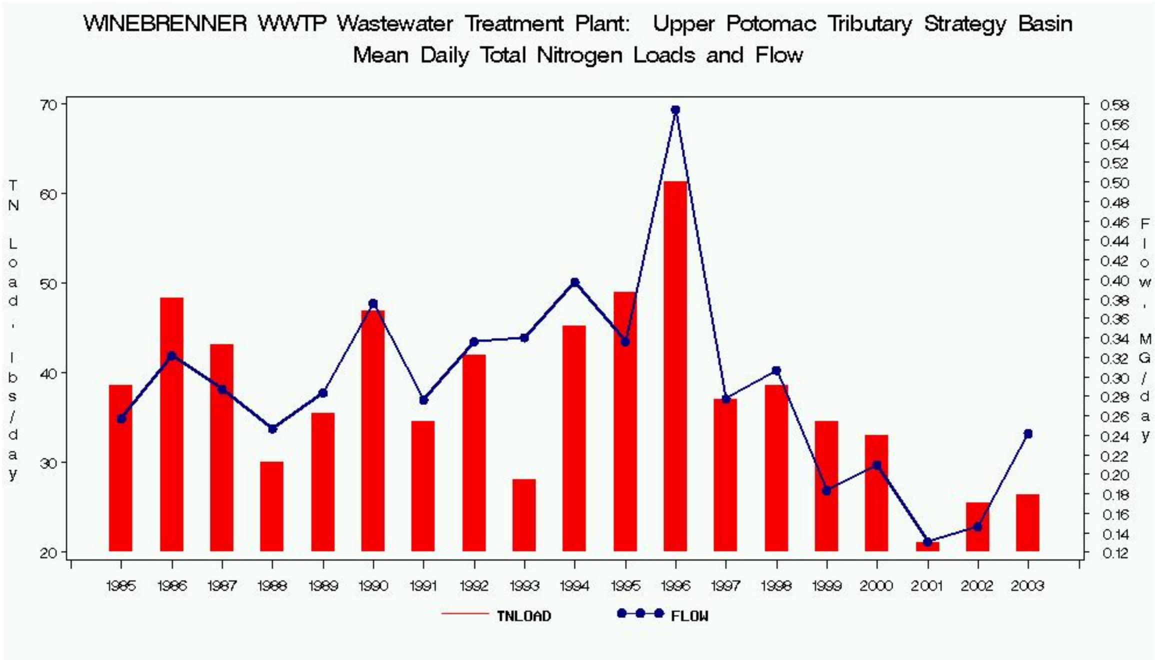


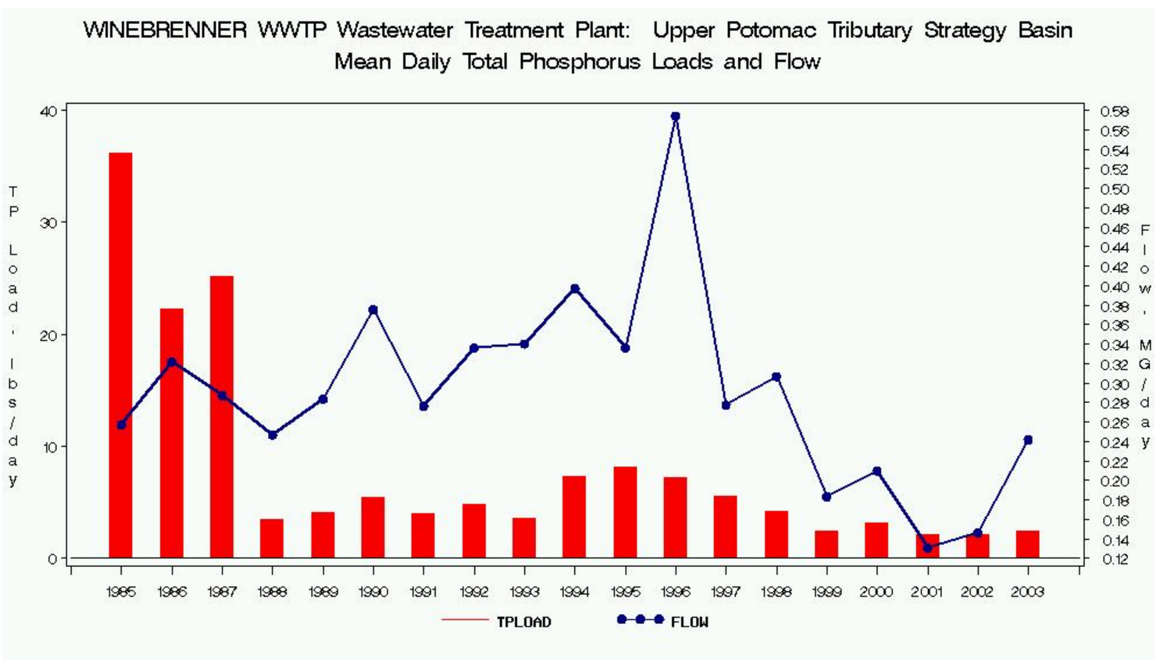

WESTMINSTER Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
100
200
300
400
500
2
3
4
5
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TNLOAD
FLOW


WESTMINSTER Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
10
20
30
40
50
60
70
80
2
3
4
5
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
TPLOAD
FLOW


WESTVACO CORPORATION–LUKE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW


WESTVACO CORPORATION–LUKE Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW


WINEBRENNER WWTP Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Nitrogen Loads and Flow
TN Load, lbs/day
Flow, MG/day
TNLOAD
FLOW

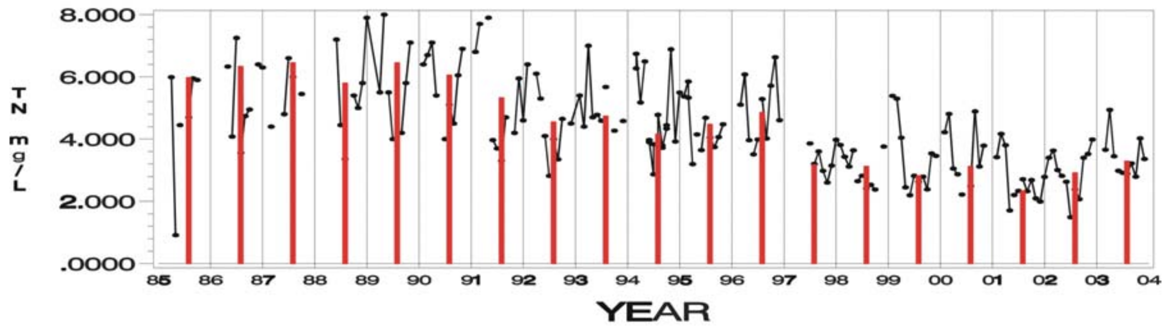

WINEBRENNER WWTP Wastewater Treatment Plant: Upper Potomac Tributary Strategy Basin
Mean Daily Total Phosphorus Loads and Flow
TP Load, lbs/day
Flow, MG/day
TPLOAD
FLOW

Appendix B – Measured Water Quality Concentrations for the Upper Potomac River Basin

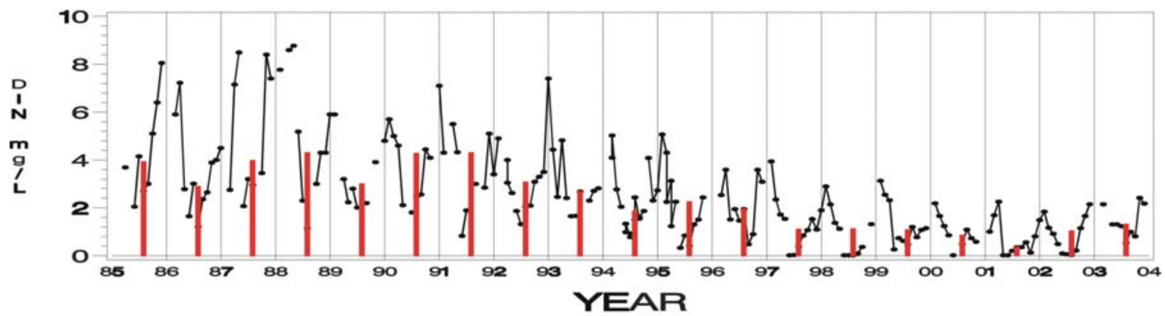
Water quality concentrations based on measured concentration data taken at long-term stations are graphed as follows. Mean concentration for the surface data are shown for each sampling date as black dots. Annual median of those values is shown as red bar.

Note that parameter values tend to fluctuate highly from year to year, and much of this fluctuation can be attributed to flow conditions. For example, in high flow years (wet years), nutrient levels are higher than in dry years. Topography, hydrogeology, stream hydrology, how a basin is developed, and management actions all affect the influence of weather conditions.

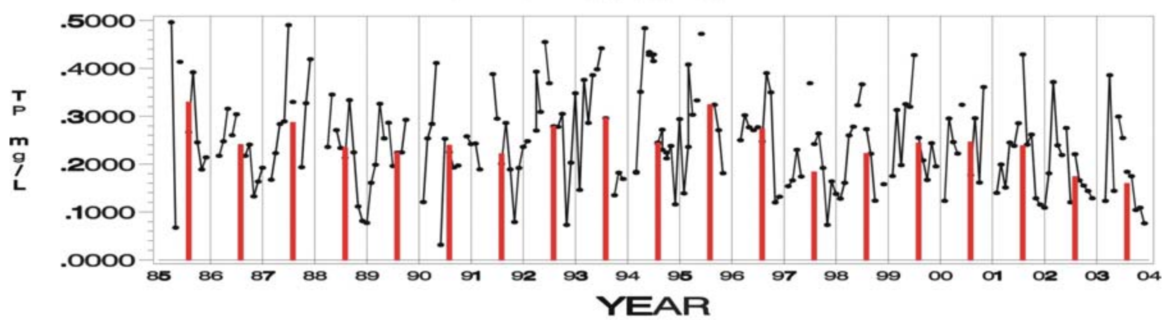
Total Nitrogen at WT4.1 (Back River), 1985 – 2003, layer = SAP
red bar = annual median



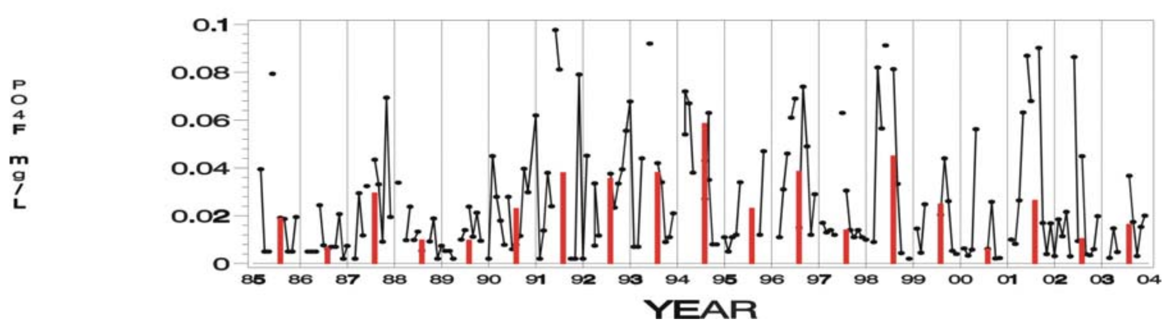
Dissolved Inorganic Nitrogen at WT4.1 (Back River), 1985 – 2003, layer = SAP
red bar = annual median



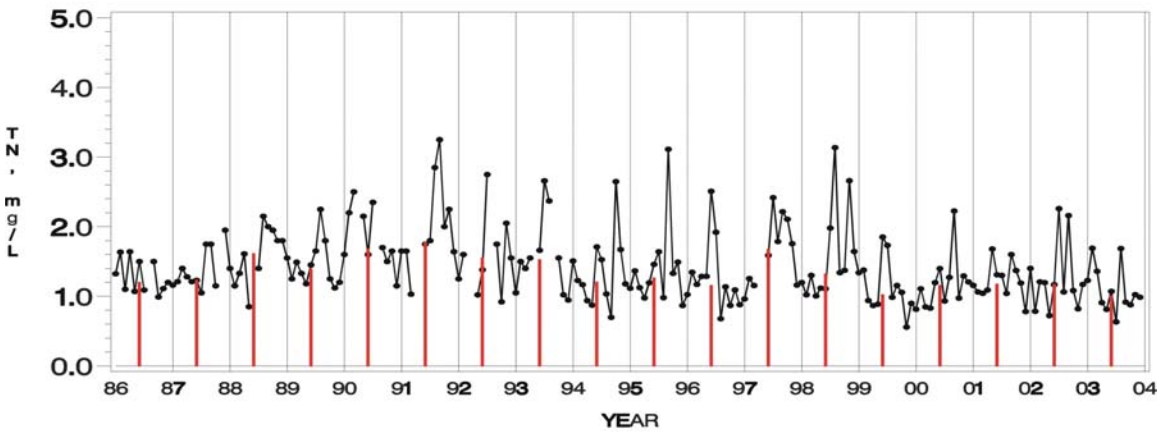
Total Phosphorus at WT4.1 (Back River), 1985 – 2003, layer = SAP
red bar = annual median



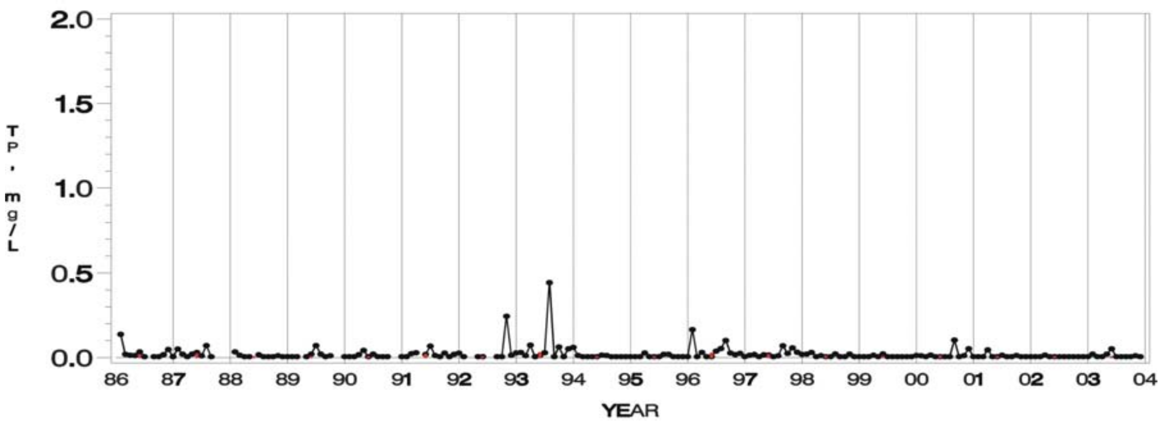
Orthophosphate at WT4.1 (Back River), 1985 – 2003, layer = SAP
red bar = annual median



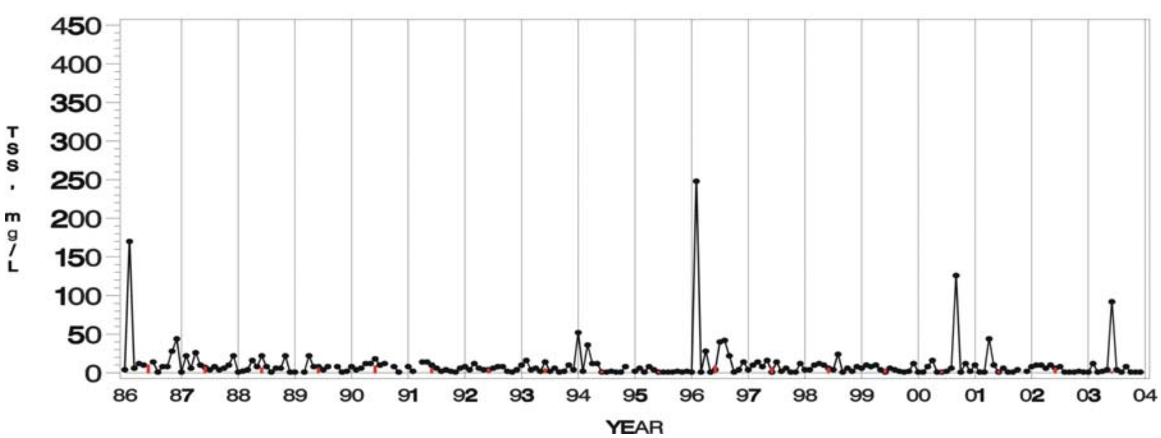
Total Nitrogen at NBP0689 (Route 38), 1986−2003, layer=S
red bar = annual median

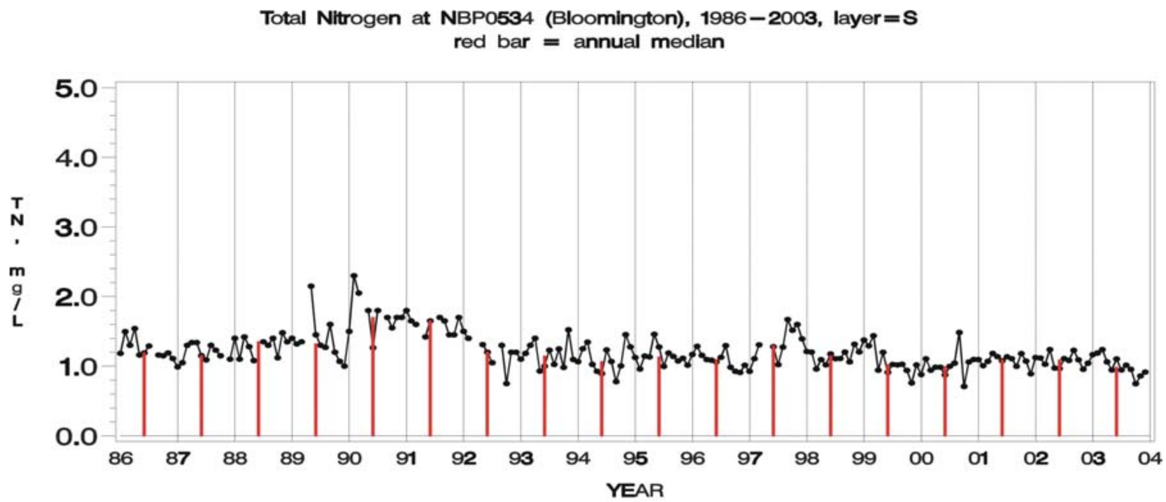


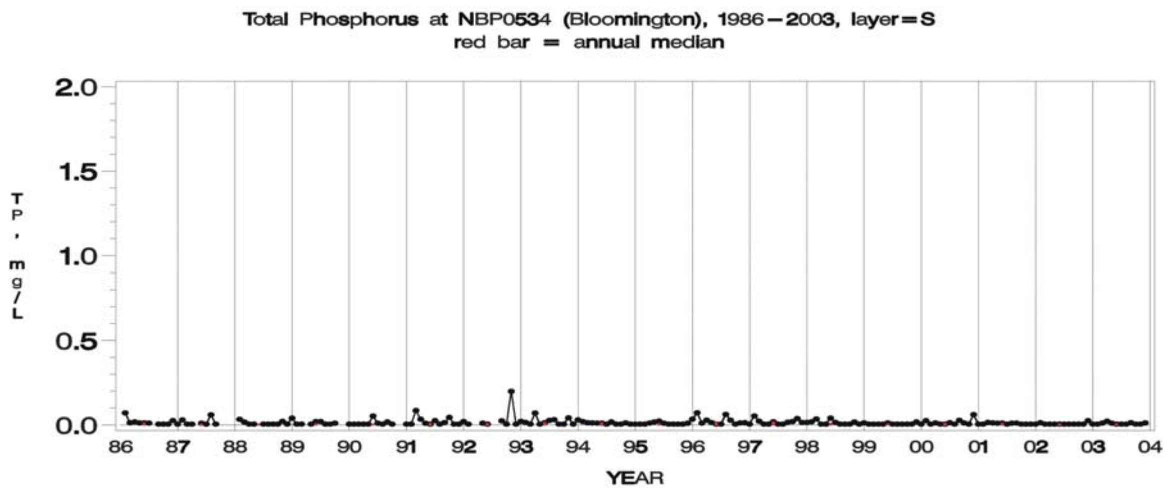
Total Phosphorus at NBP0689 (Route 38), 1986−2003, layer=S
red bar = annual median

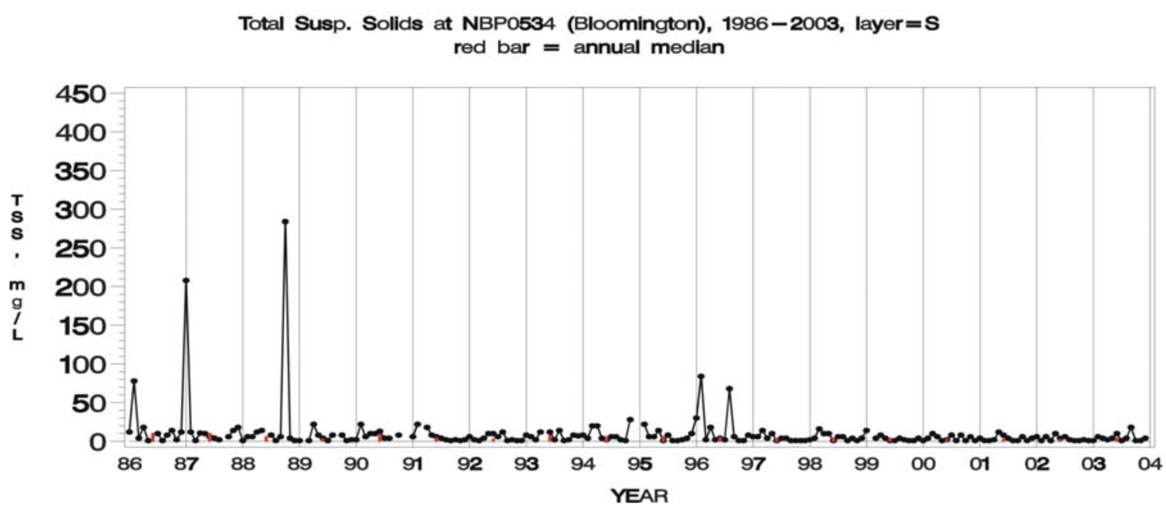


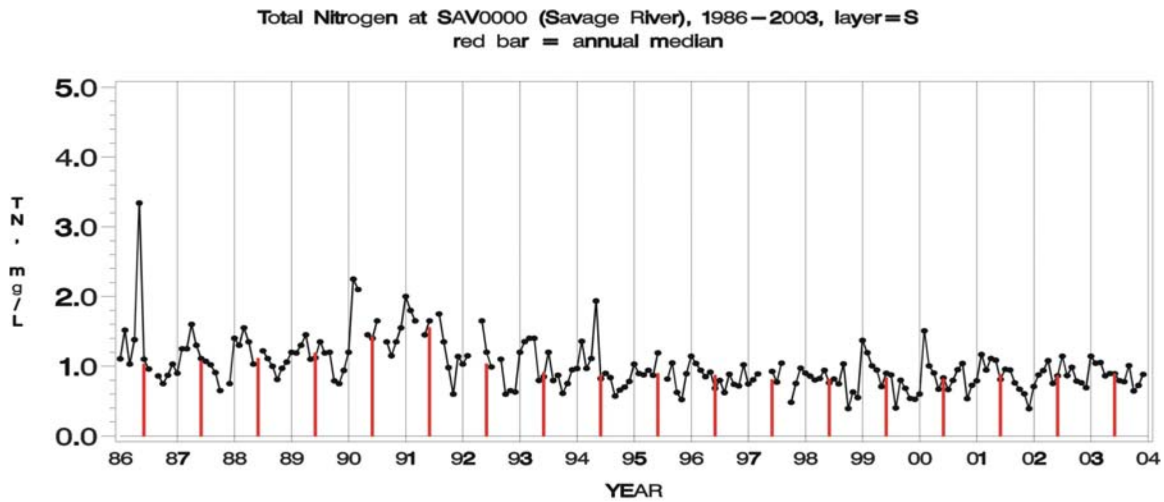
Total Susp. Solids at NBP0689 (Route 38), 1986−2003, layer=S
red bar = annual median

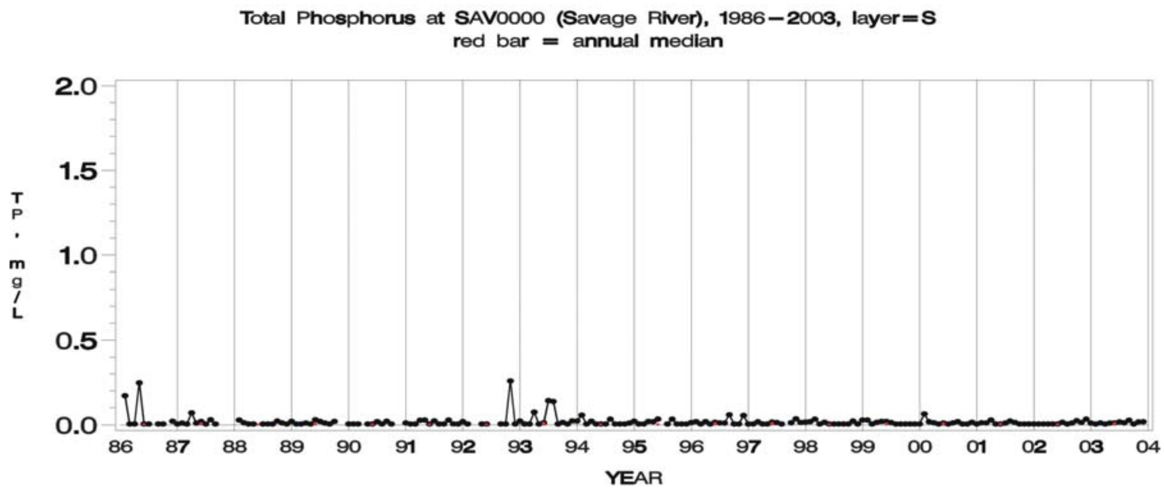


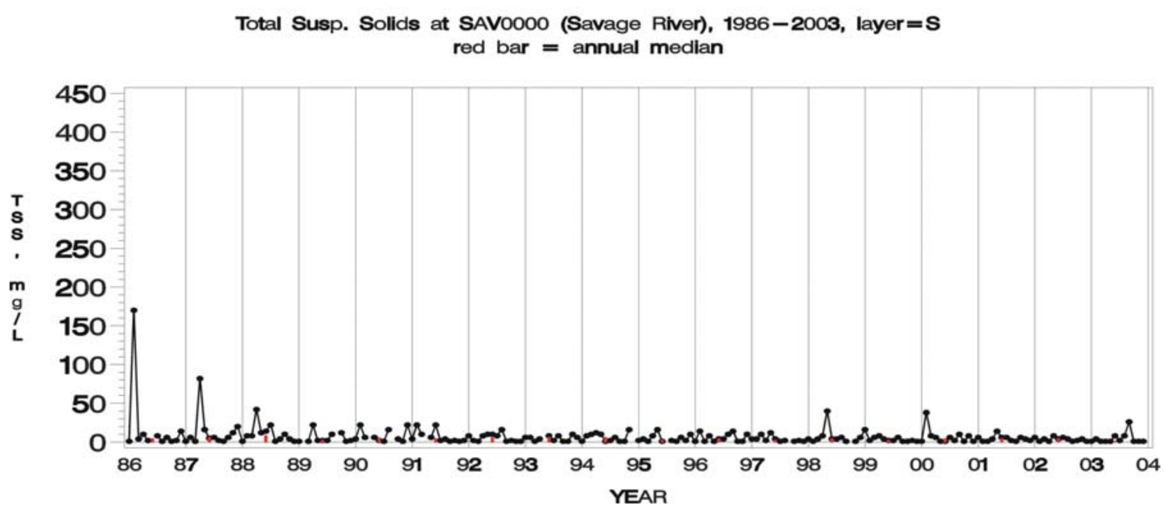

Total Nitrogen at NBP0534 (Bloomington), 1986-2003, layer=S
red bar = annual median
TN, mg/L
5.0
4.0
3.0
2.0
1.0
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Phosphorus at NBP0534 (Bloomington), 1986-2003, layer=S
red bar = annual median
TP, mg/L
2.0
1.5
1.0
0.5
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

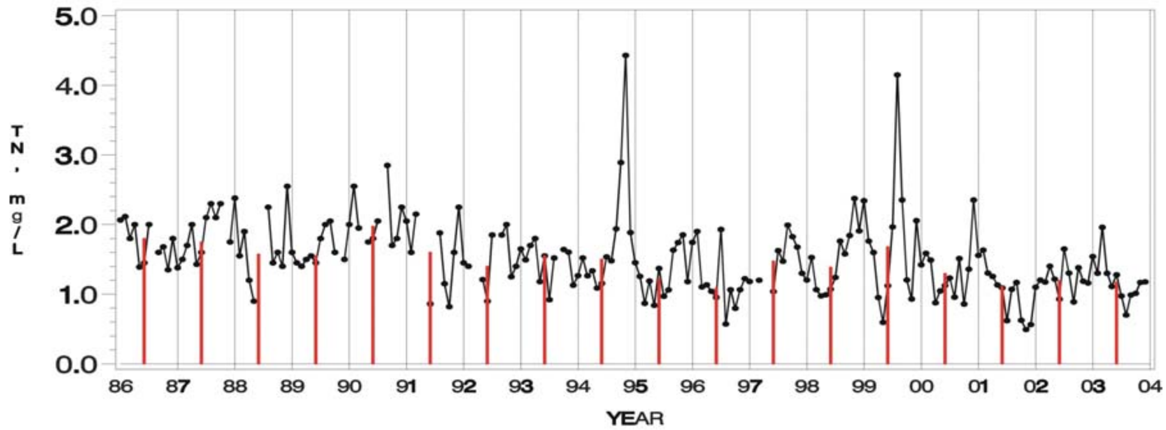

Total Susp. Solids at NBP0534 (Bloomington), 1986-2003, layer=S
red bar = annual median
TSS, mg/L
450
400
350
300
250
200
150
100
50
0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Nitrogen at SAV0000 (Savage River), 1986-2003, layer=S
red bar = annual median
TN, mg/L
5.0
4.0
3.0
2.0
1.0
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

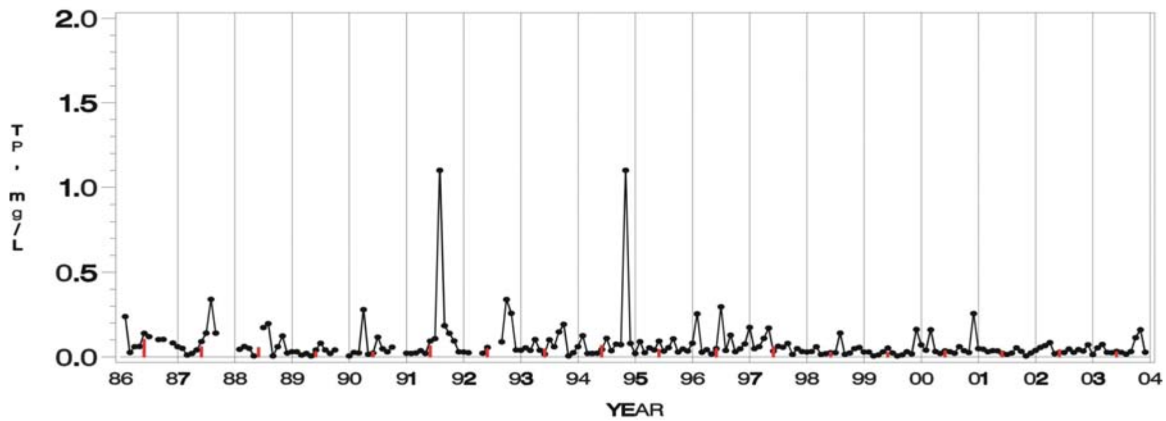

Total Phosphorus at SAV0000 (Savage River), 1986-2003, layer=S
red bar = annual median
TP, mg/L
2.0
1.5
1.0
0.5
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Susp. Solids at SAV0000 (Savage River), 1986-2003, layer=S
red bar = annual median
TSS, mg/L
450
400
350
300
250
200
150
100
50
0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

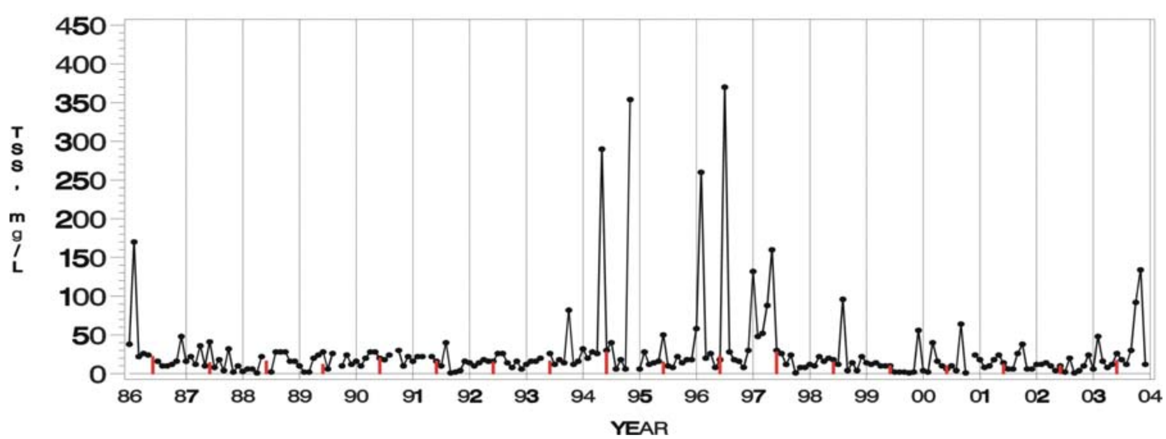
Total Nitrogen at GEO0009 (George''s Creek), 1986-2003, layer=S
red bar = annual median

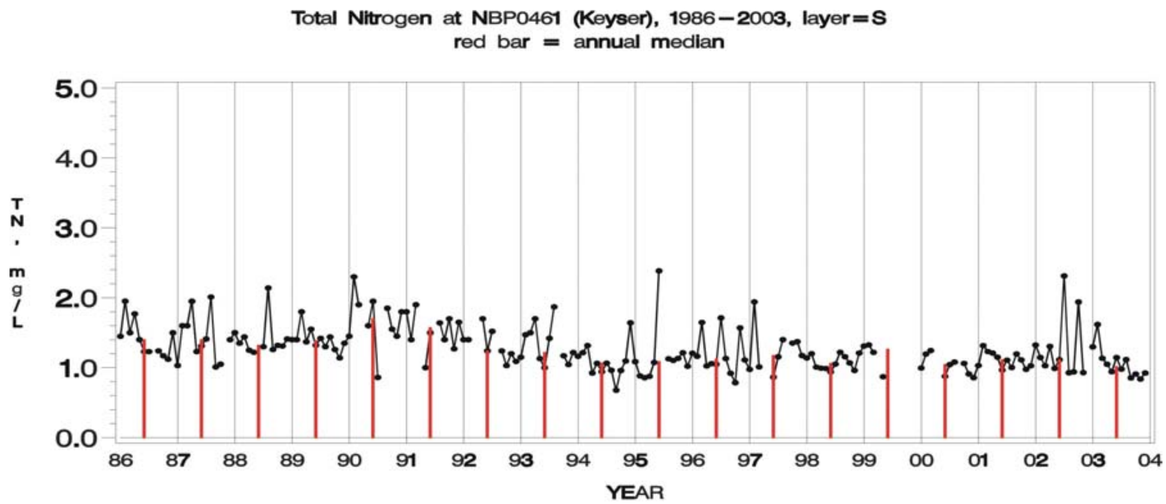


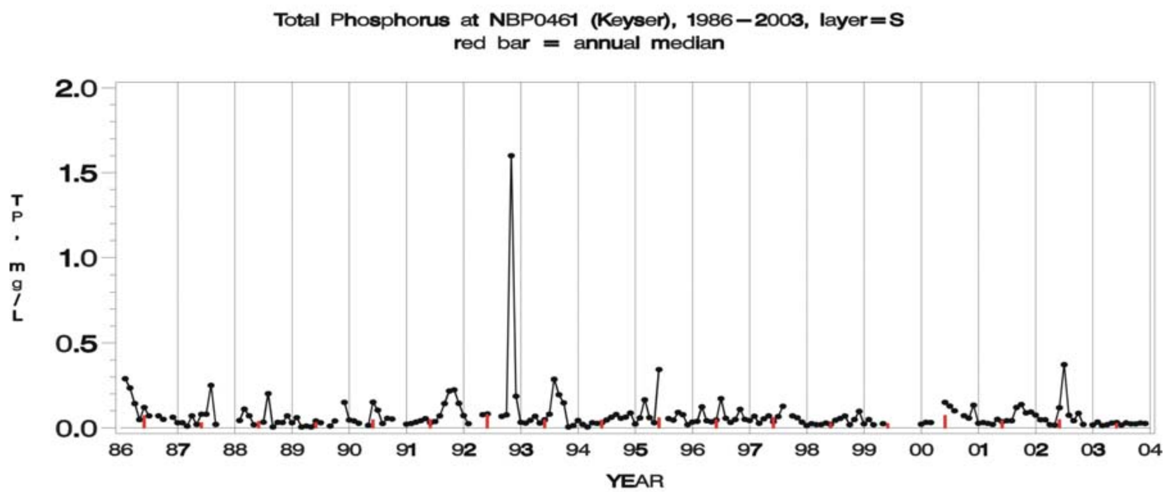
Total Phosphorus at GEO0009 (George''s Creek), 1986-2003, layer=S
red bar = annual median

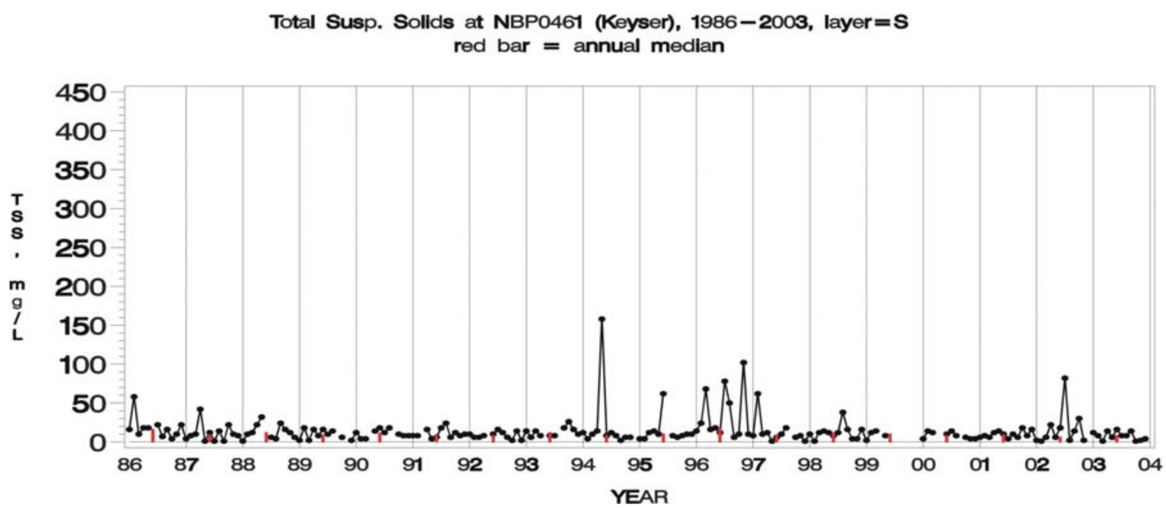


Total Susp. Solids at GEO0009 (George''s Creek), 1986-2003, layer=S
red bar = annual median

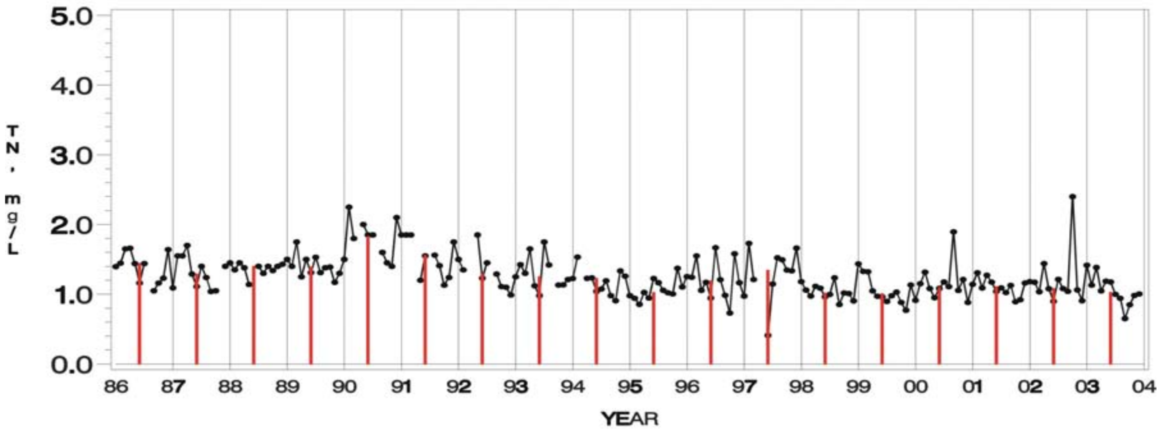



Total Nitrogen at NBP0461 (Keyser), 1986–2003, layer=S
red bar = annual median
TN, mg/L
YEAR

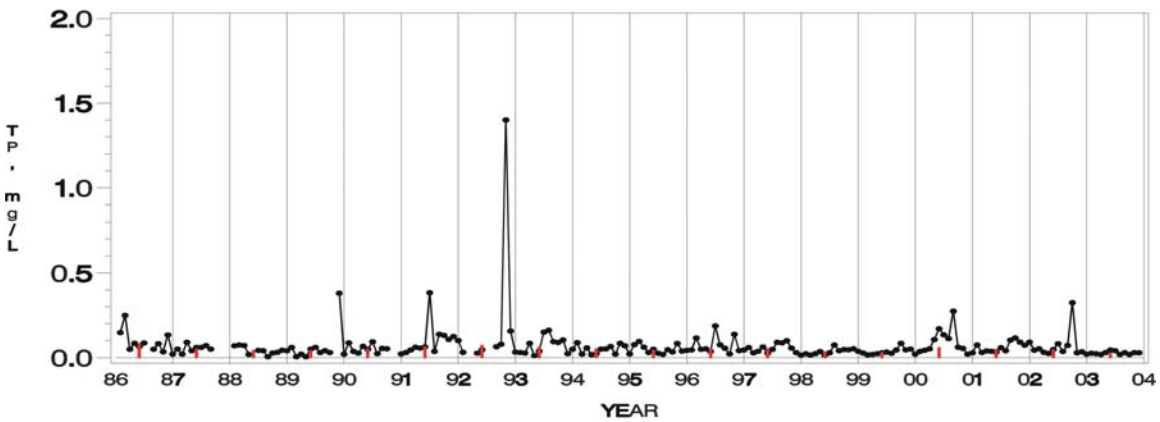

Total Phosphorus at NBP0461 (Keyser), 1986–2003, layer=S
red bar = annual median
TP, mg/L
YEAR


Total Susp. Solids at NBP0461 (Keyser), 1986–2003, layer=S
red bar = annual median
TSS, mg/L
YEAR

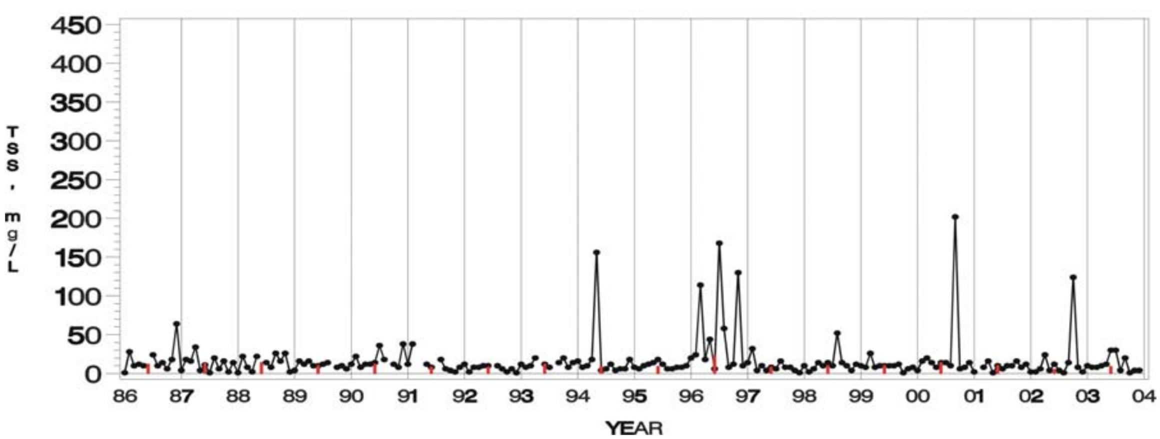
Total Nitrogen at NBP0326 (Pinto), 1986–2003, layer=S
red bar = annual median



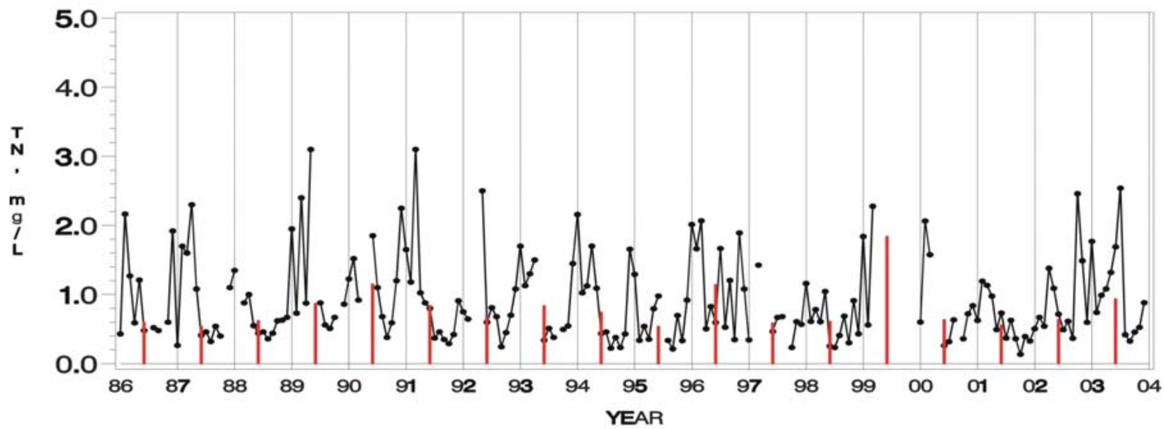
Total Phosphorus at NBP0326 (Pinto), 1986–2003, layer=S
red bar = annual median



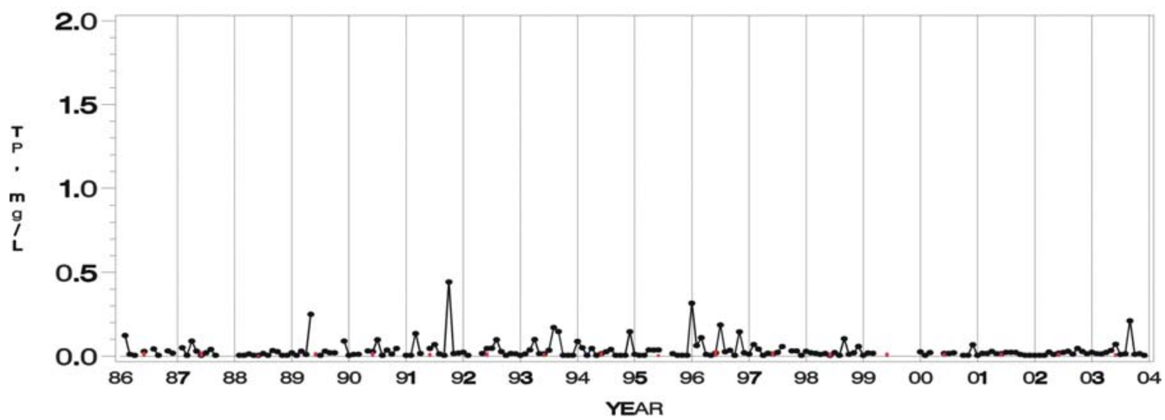
Total Susp. Solids at NBP0326 (Pinto), 1986–2003, layer=S
red bar = annual median



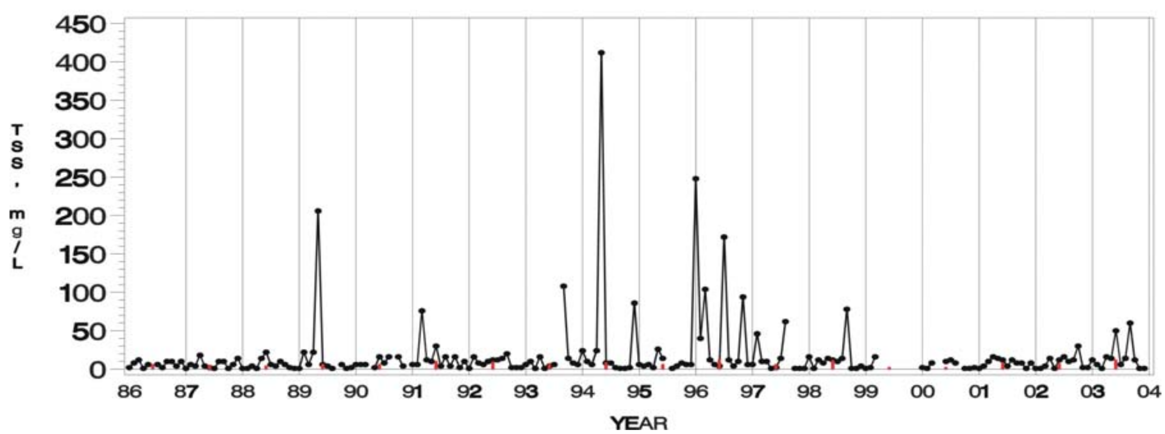
Total Nitrogen at BDK0000 (Braddock Run), 1986–2003, layer=S
red bar = annual median

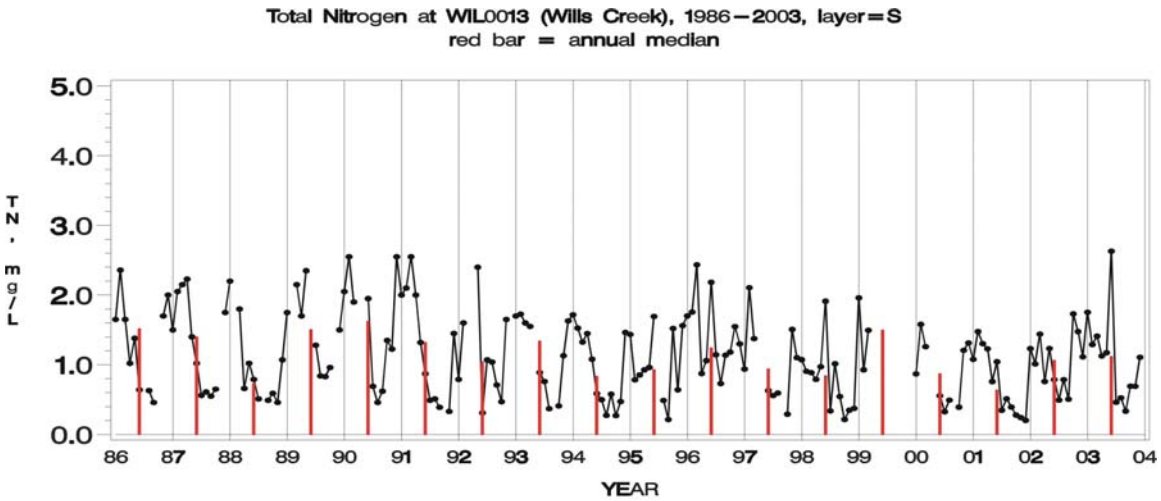


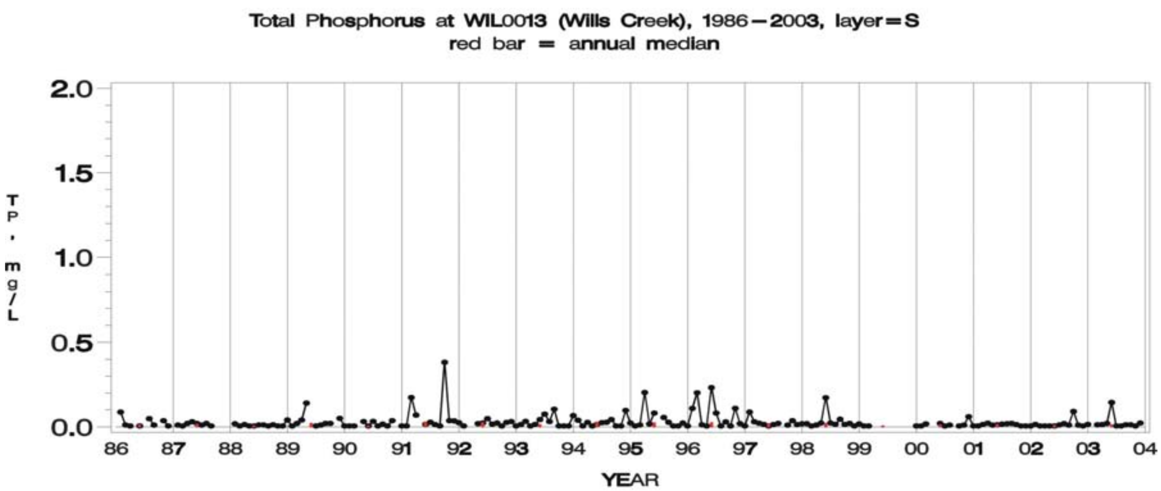
Total Phosphorus at BDK0000 (Braddock Run), 1986–2003, layer=S
red bar = annual median

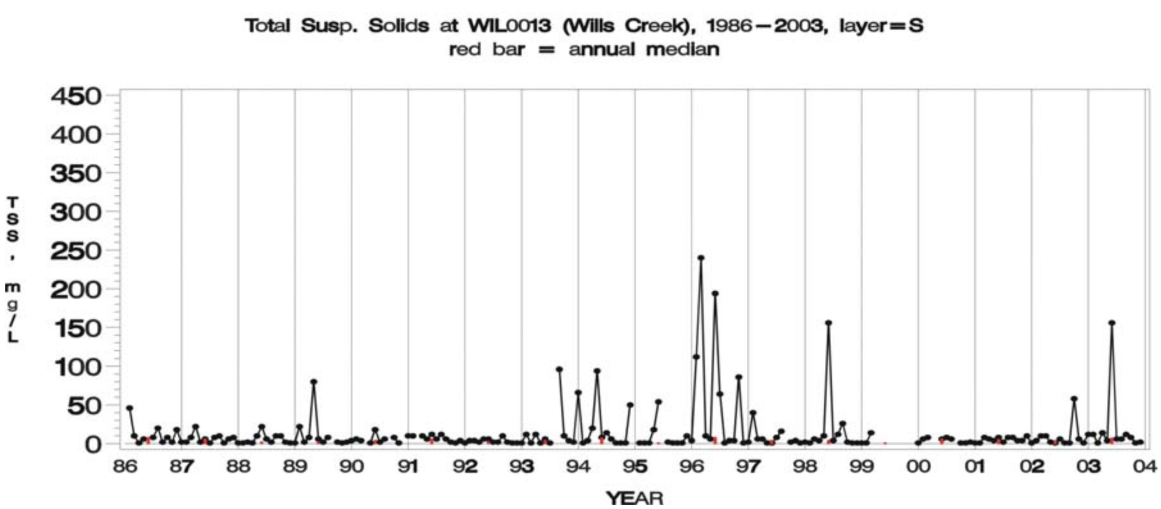


Total Susp. Solids at BDK0000 (Braddock Run), 1986–2003, layer=S
red bar = annual median

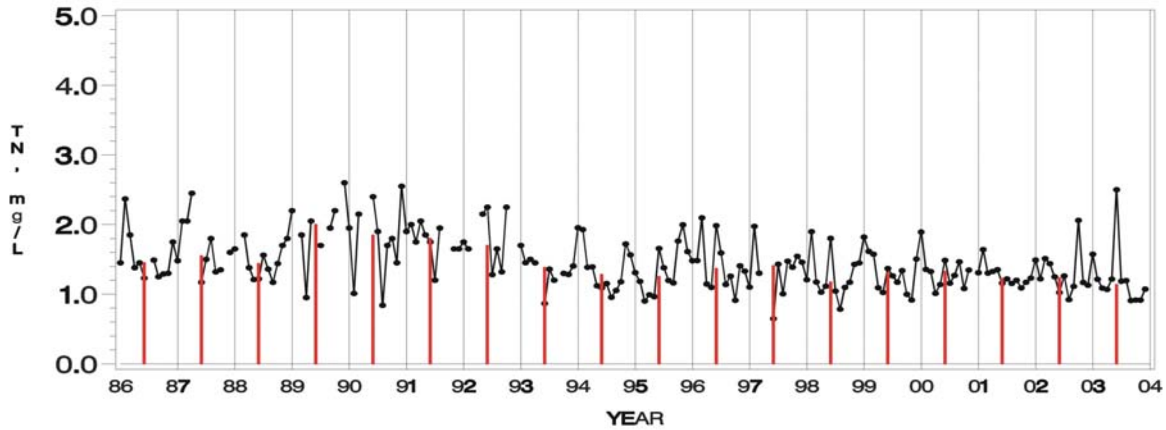



Total Nitrogen at WIL0013 (Wills Creek), 1986-2003, layer=S
red bar = annual median
TN, mg/L
YEAR
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
0.0 1.0 2.0 3.0 4.0 5.0

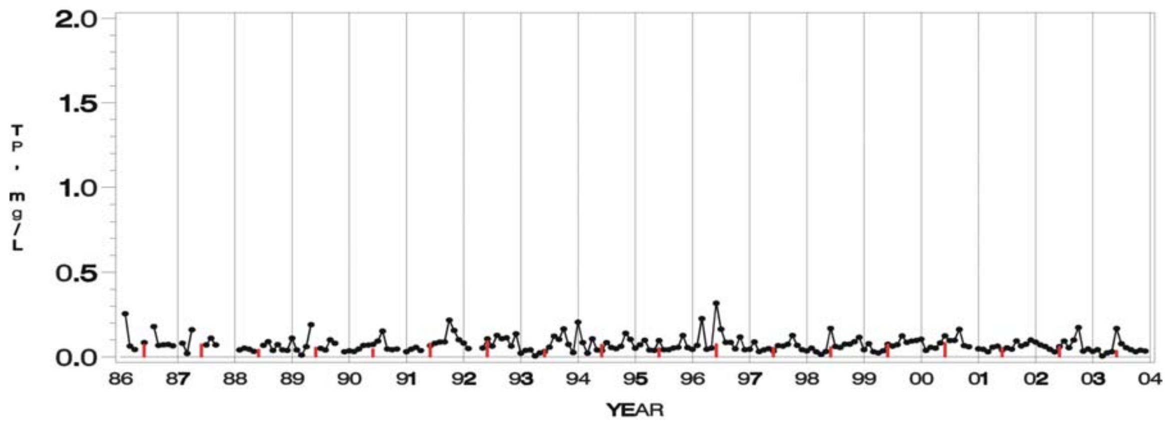

Total Phosphorus at WIL0013 (Wills Creek), 1986-2003, layer=S
red bar = annual median
TP, mg/L
YEAR
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
0.0 0.5 1.0 1.5 2.0


Total Susp. Solids at WIL0013 (Wills Creek), 1986-2003, layer=S
red bar = annual median
TSS, mg/L
YEAR
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
0 50 100 150 200 250 300 350 400 450

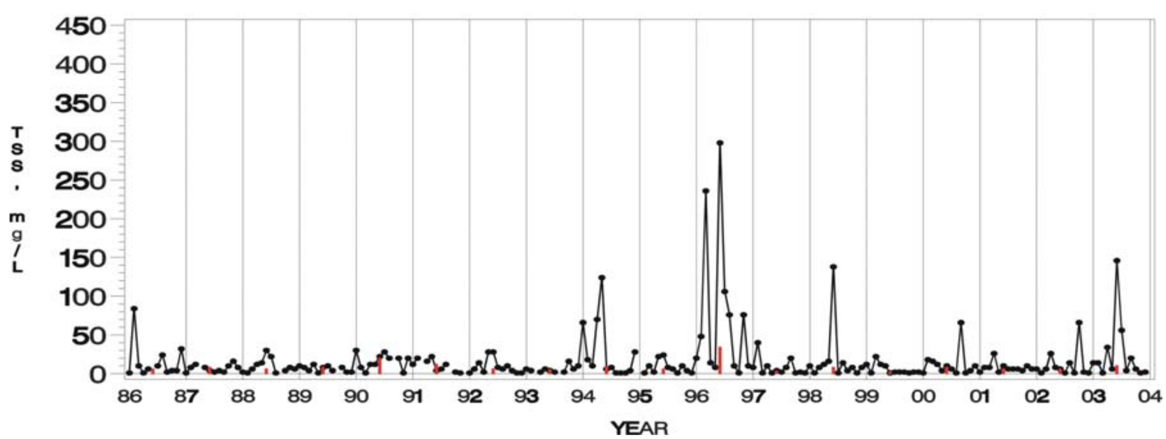
Total Nitrogen at NBP0103 (Route 51), 1986–2003, layer=S
red bar = annual median

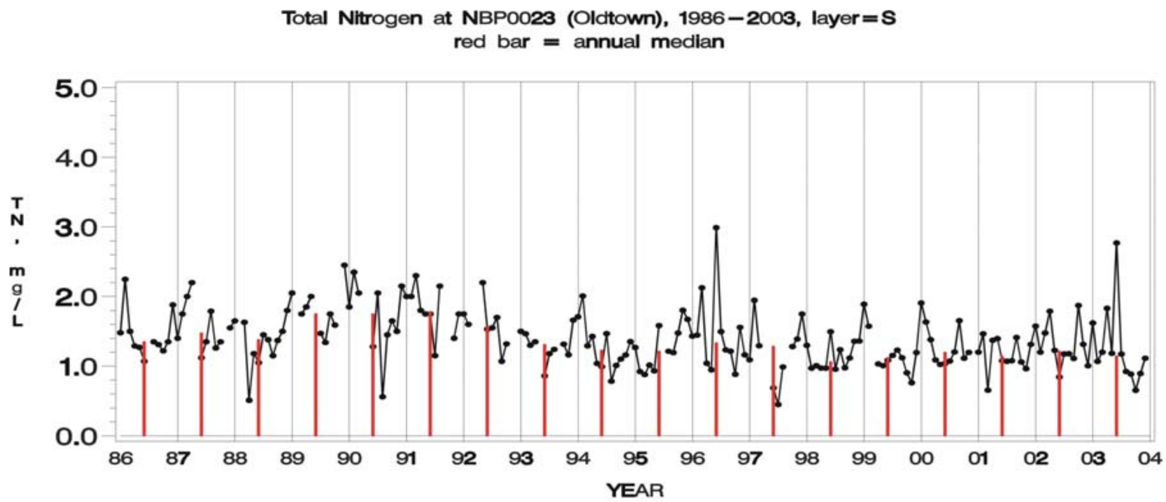


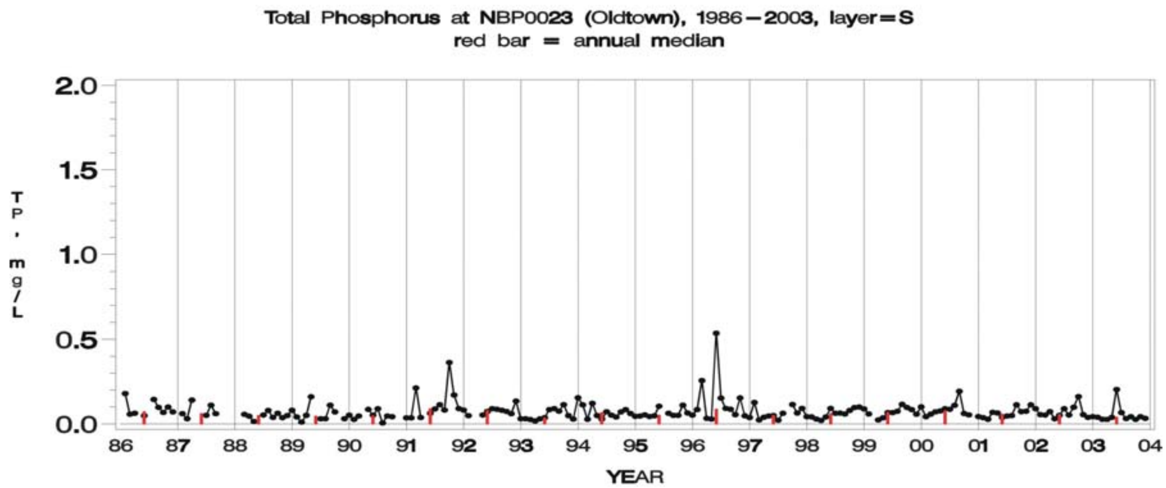
Total Phosphorus at NBP0103 (Route 51), 1986–2003, layer=S
red bar = annual median

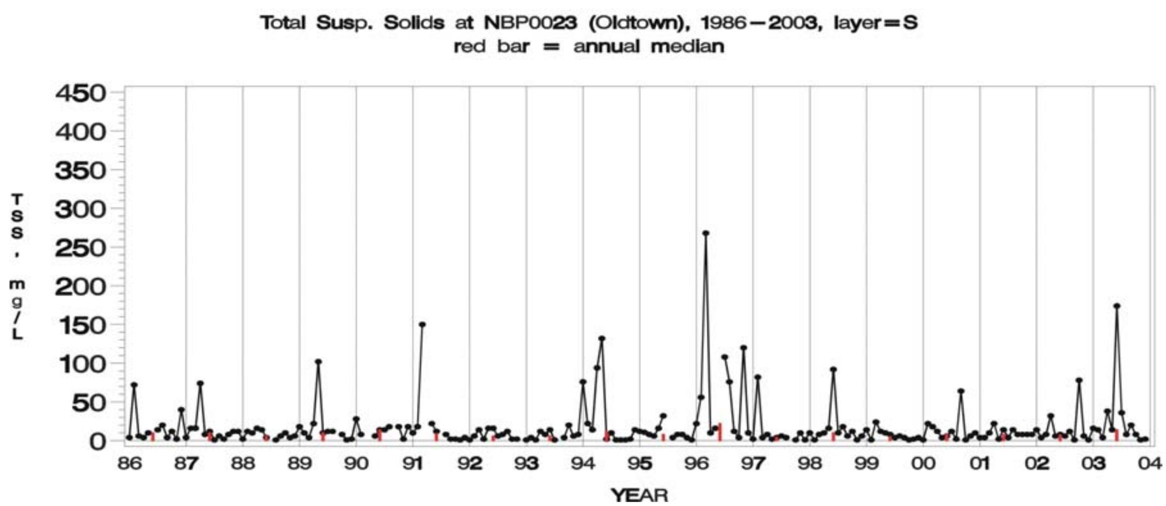


Total Susp. Solids at NBP0103 (Route 51), 1986–2003, layer=S
red bar = annual median

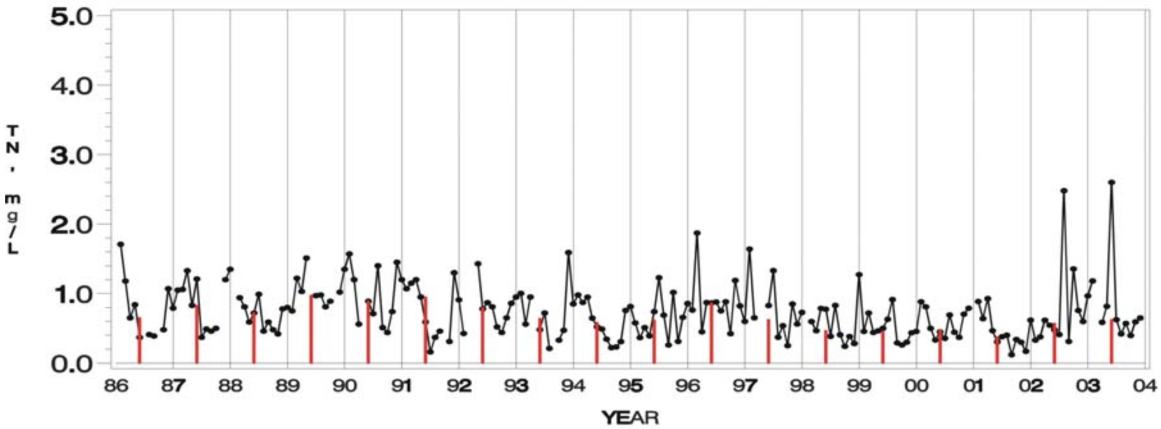



Total Nitrogen at NBP0023 (Oldtown), 1986–2003, layer=S
red bar = annual median
TN, mg/L
5.0
4.0
3.0
2.0
1.0
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

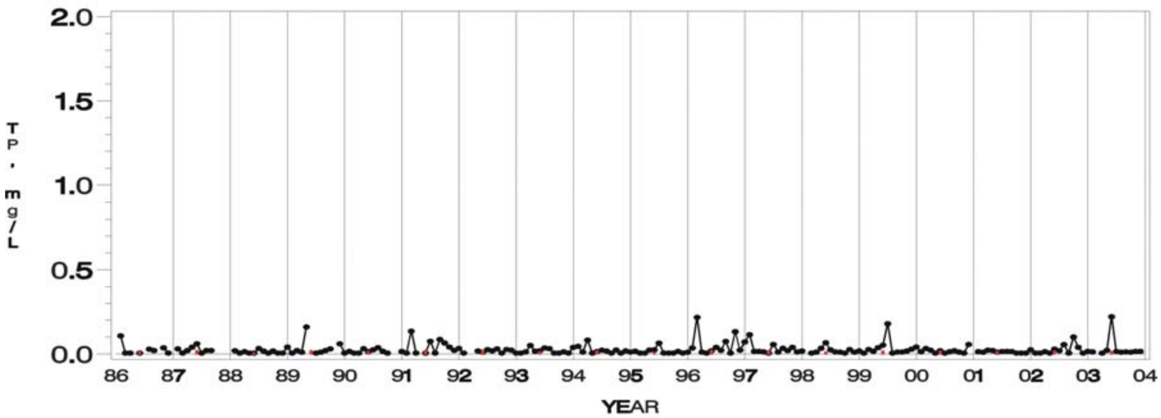

Total Phosphorus at NBP0023 (Oldtown), 1986–2003, layer=S
red bar = annual median
TP, mg/L
2.0
1.5
1.0
0.5
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Susp. Solids at NBP0023 (Oldtown), 1986–2003, layer=S
red bar = annual median
TSS, mg/L
450
400
350
300
250
200
150
100
50
0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

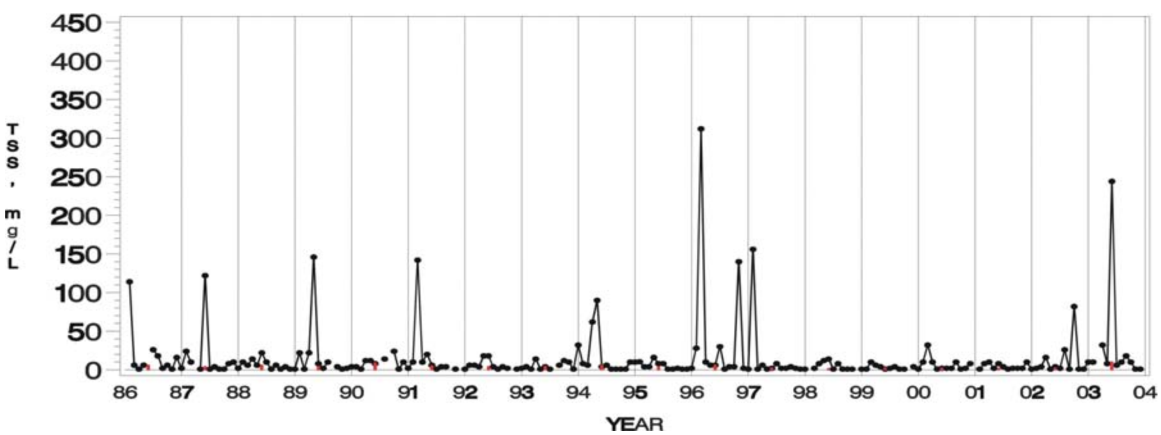
Total Nitrogen at TOW0030 (Town Creek), 1986–2003, layer=S
red bar = annual median



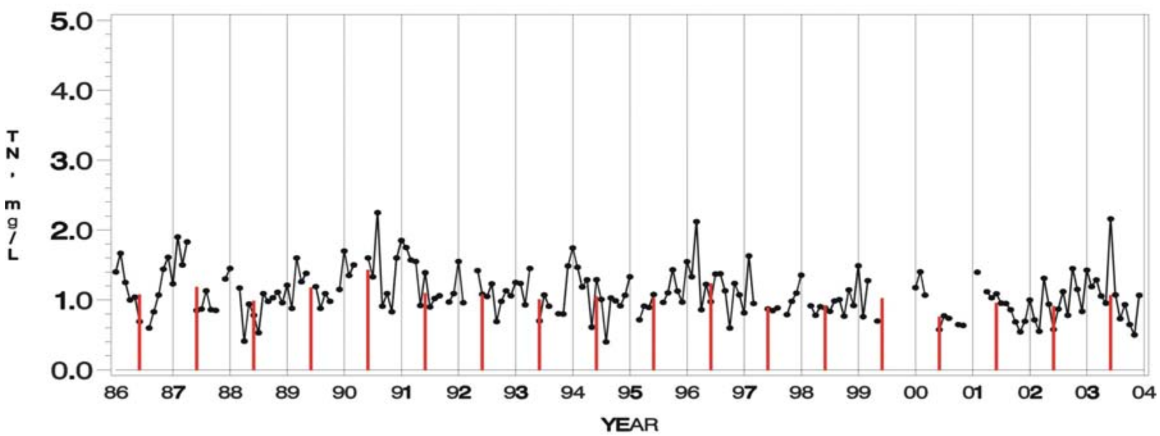
Total Phosphorus at TOW0030 (Town Creek), 1986–2003, layer=S
red bar = annual median



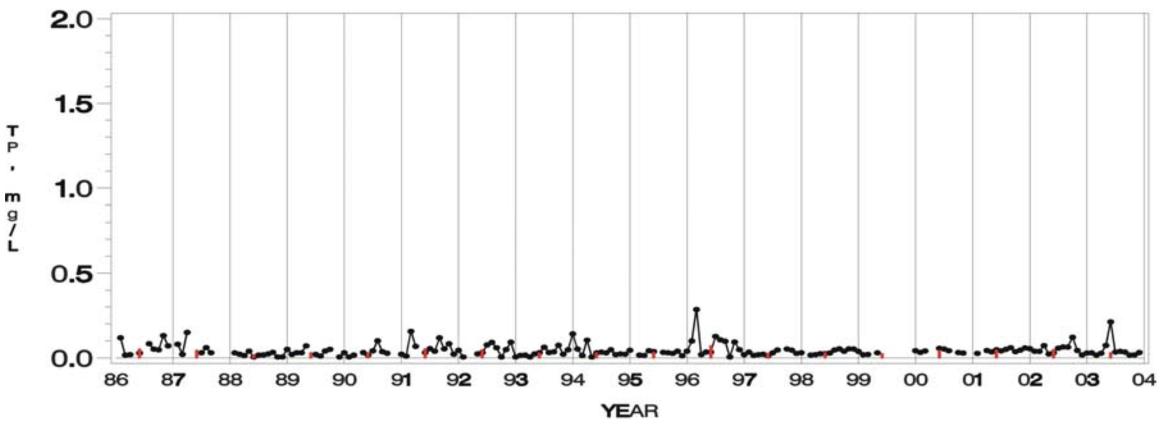
Total Susp. Solids at TOW0030 (Town Creek), 1986–2003, layer=S
red bar = annual median



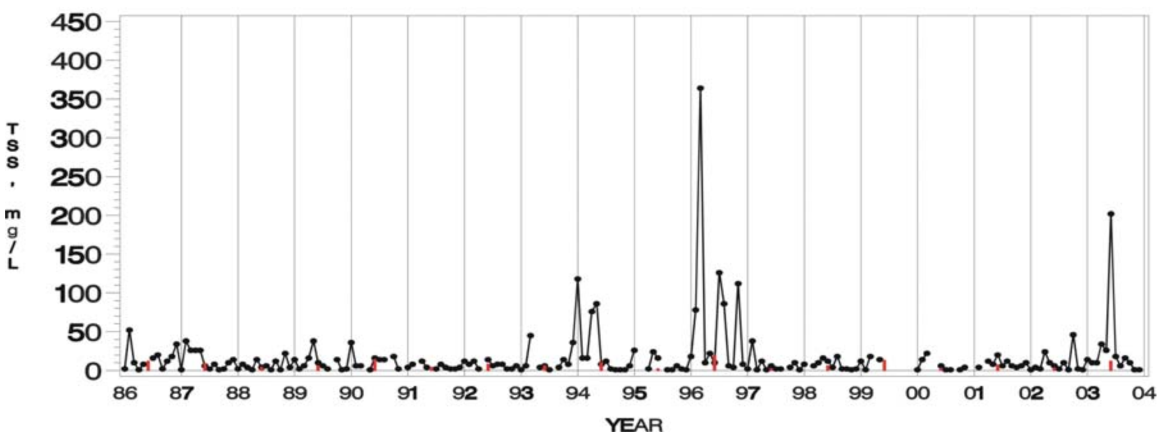
Total Nitrogen at POT2766 (Paw Paw), 1986−2003, layer=S
red bar = annual median

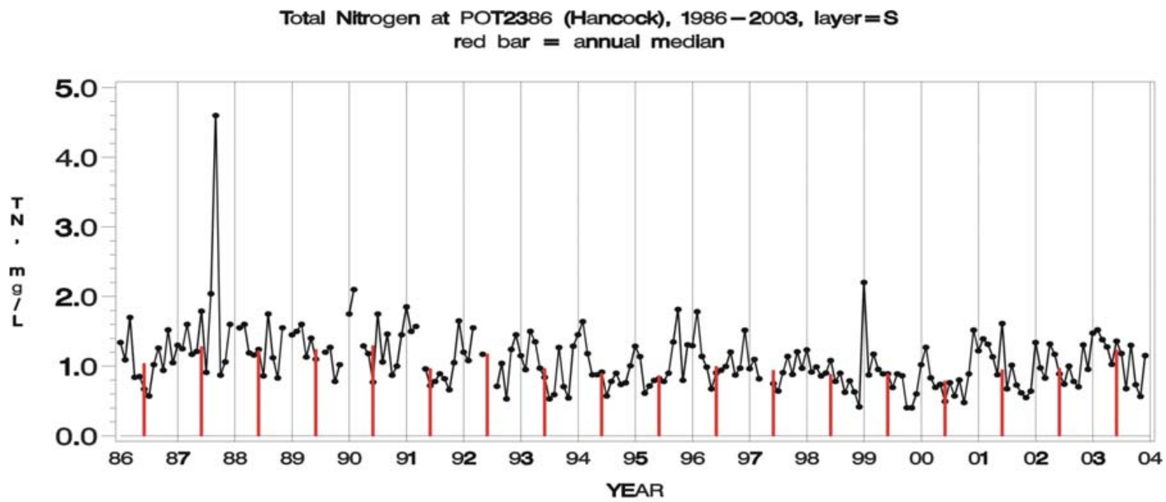


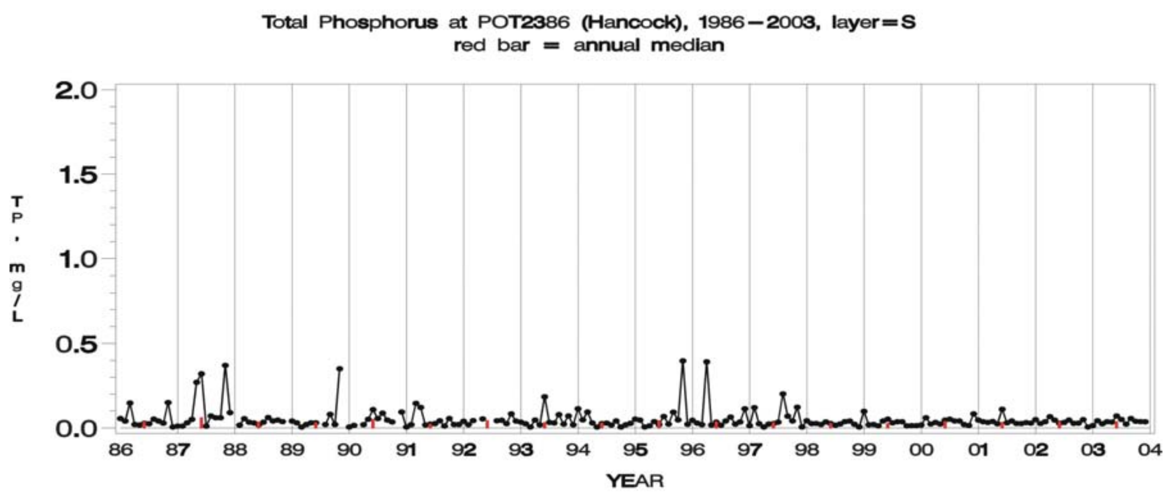
Total Phosphorus at POT2766 (Paw Paw), 1986−2003, layer=S
red bar = annual median

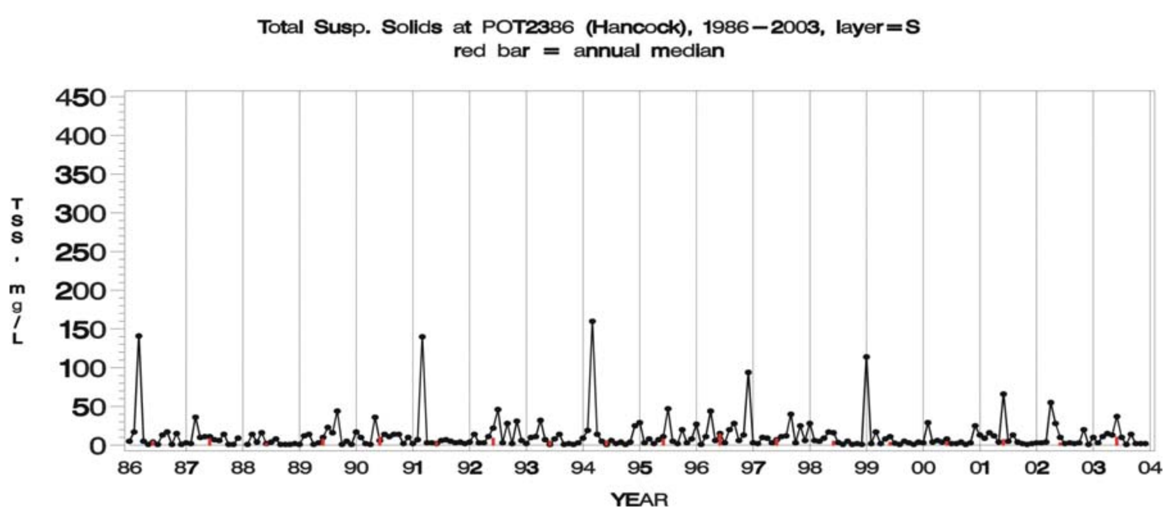


Total Susp. Solids at POT2766 (Paw Paw), 1986−2003, layer=S
red bar = annual median

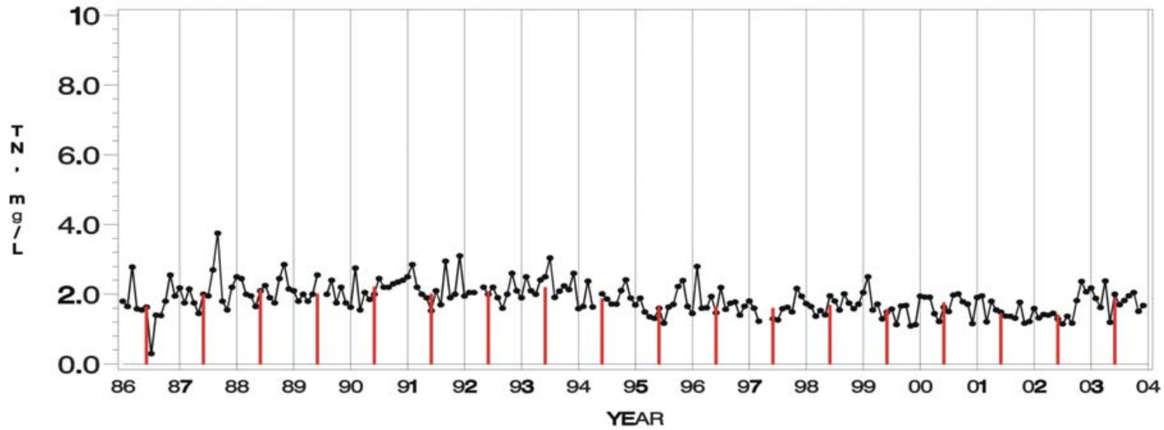



Total Nitrogen at POT2386 (Hancock), 1986−2003, layer=S
red bar = annual median
TN, mg/L
0.0
1.0
2.0
3.0
4.0
5.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

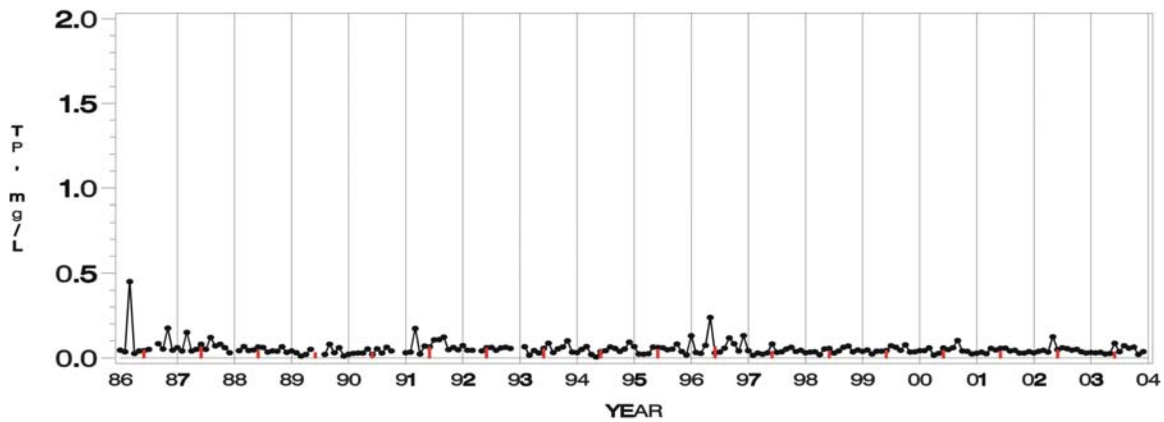

Total Phosphorus at POT2386 (Hancock), 1986−2003, layer=S
red bar = annual median
TP, mg/L
0.0
0.5
1.0
1.5
2.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Susp. Solids at POT2386 (Hancock), 1986−2003, layer=S
red bar = annual median
TSS, mg/L
0
50
100
150
200
250
300
350
400
450
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

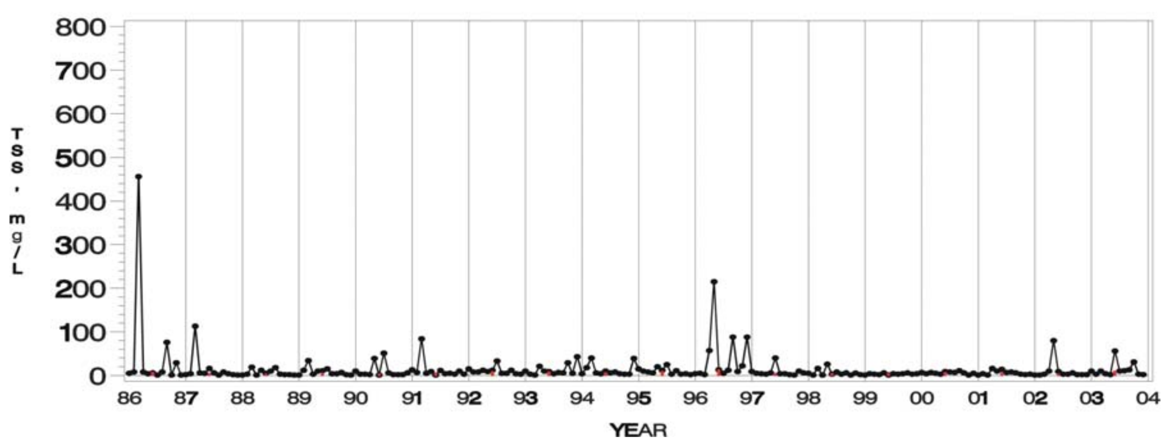
Total Nitrogen at POT1830 (Shepherdstown), 1986–2003, layer=S
red bar = annual median



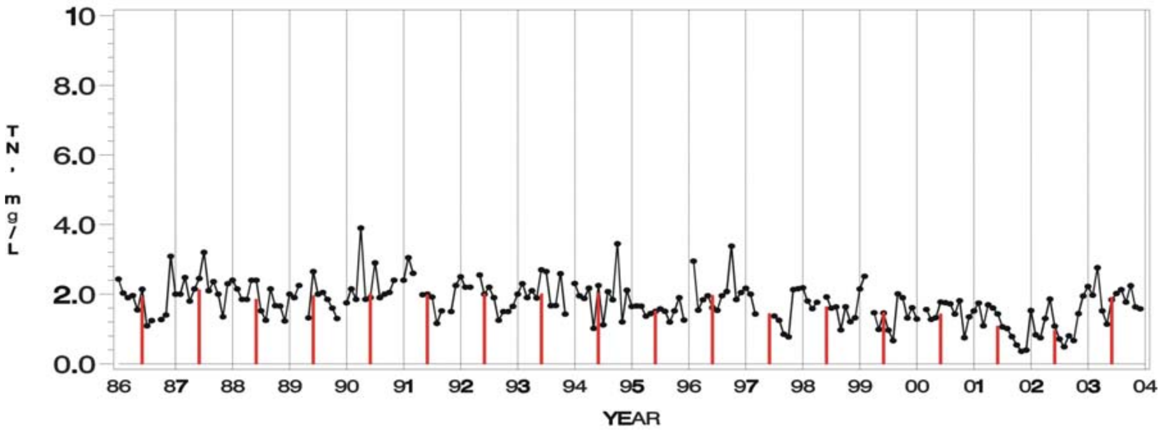
Total Phosphorus at POT1830 (Shepherdstown), 1986–2003, layer=S
red bar = annual median



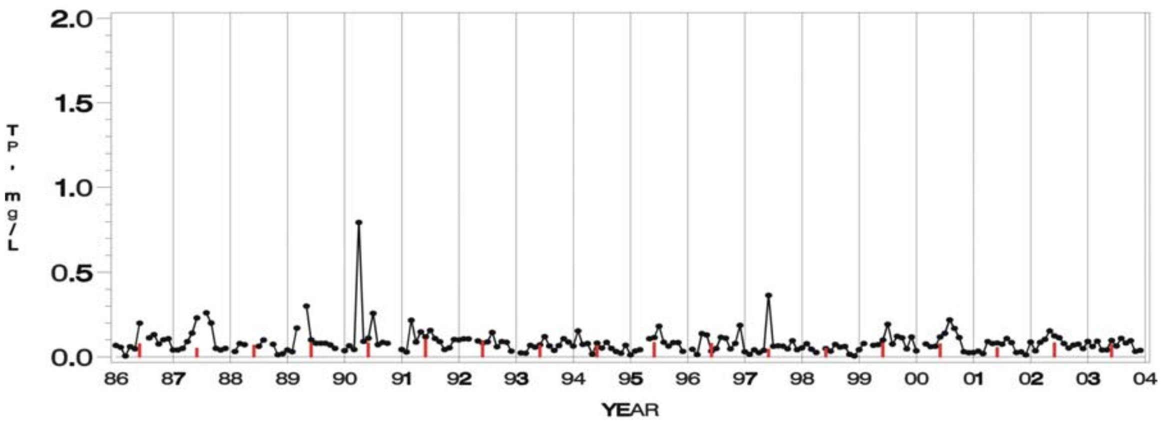
Total Susp. Solids at POT1830 (Shepherdstown), 1986–2003, layer=S
red bar = annual median



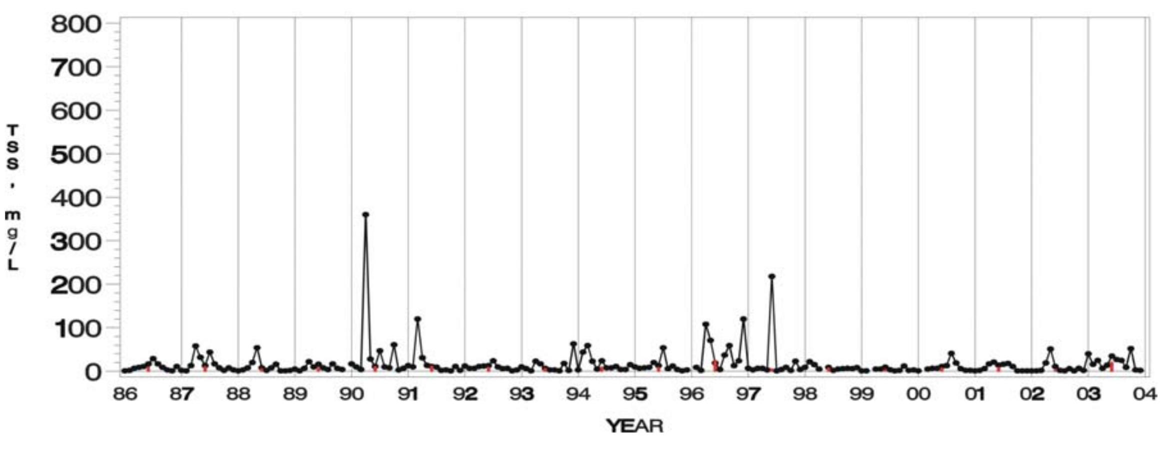
Total Nitrogen at POT1596 (Point of Rocks – VA), 1986–2003, layer=S
red bar = annual median

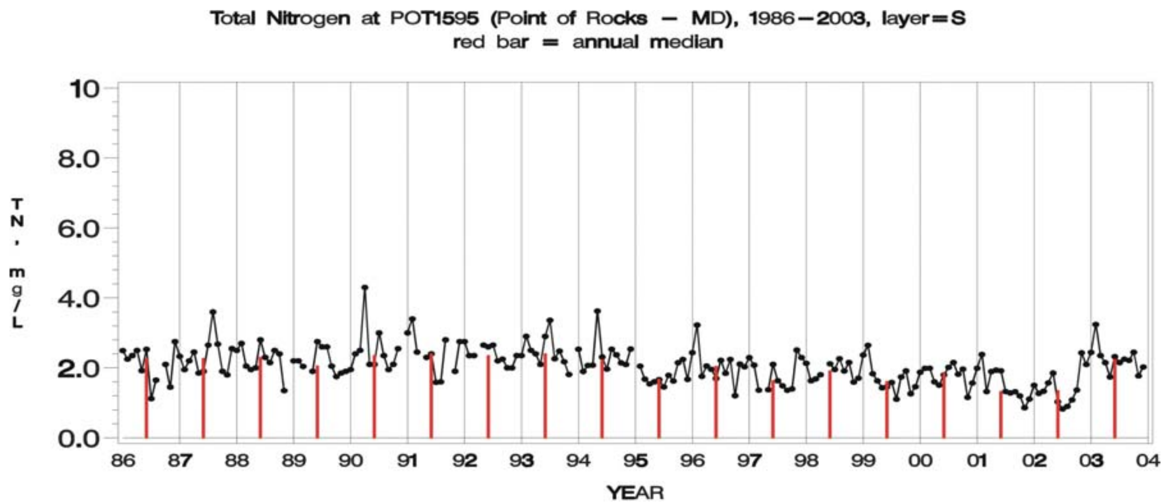


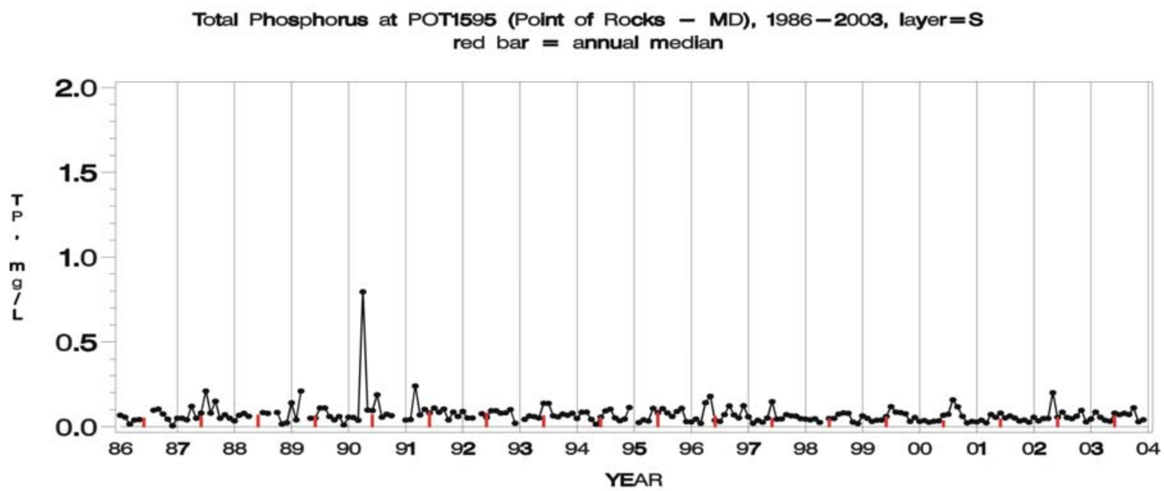
Total Phosphorus at POT1596 (Point of Rocks – VA), 1986–2003, layer=S
red bar = annual median

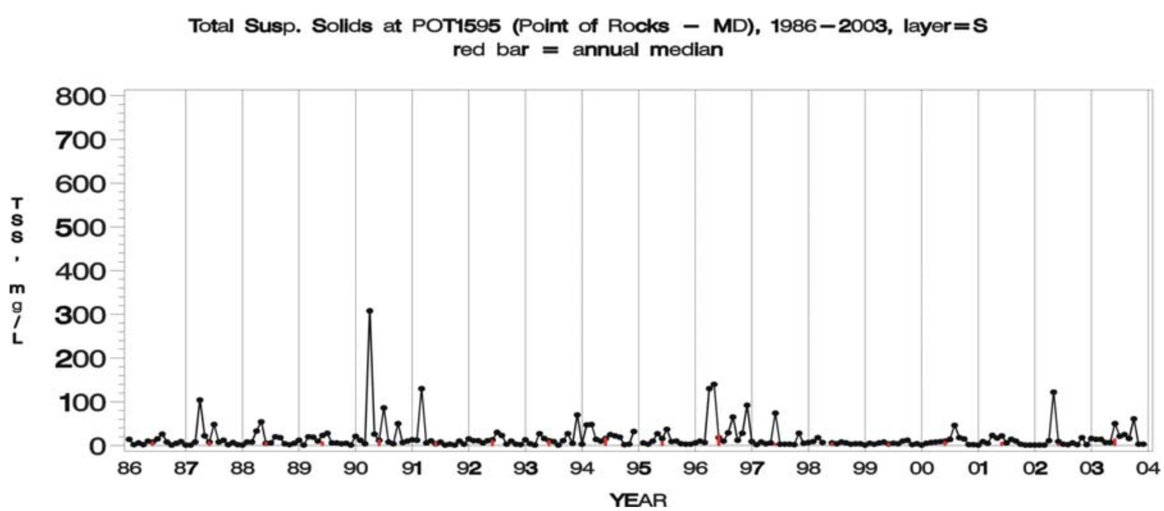


Total Susp. Solids at POT1596 (Point of Rocks – VA), 1986–2003, layer=S
red bar = annual median

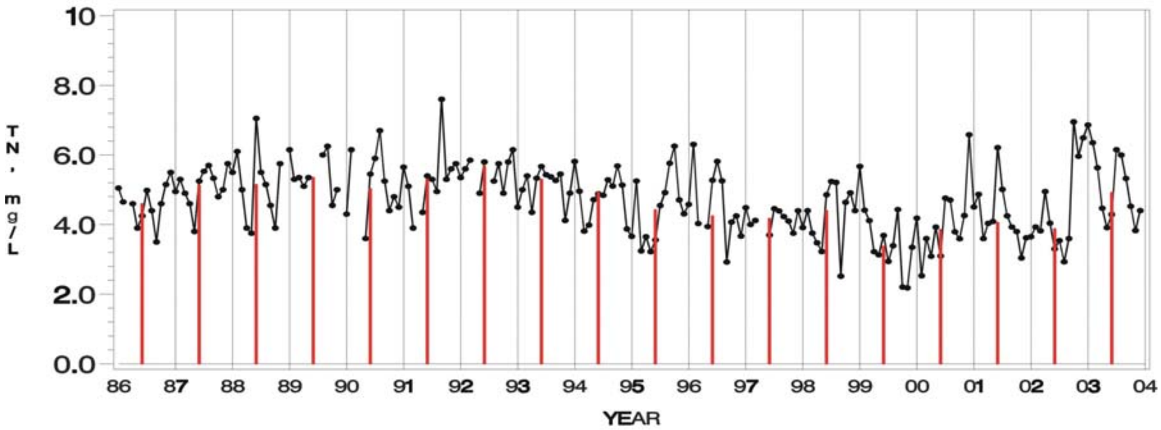



Total Nitrogen at POT1595 (Point of Rocks – MD), 1986–2003, layer=S
red bar = annual median
TN, mg/L
YEAR

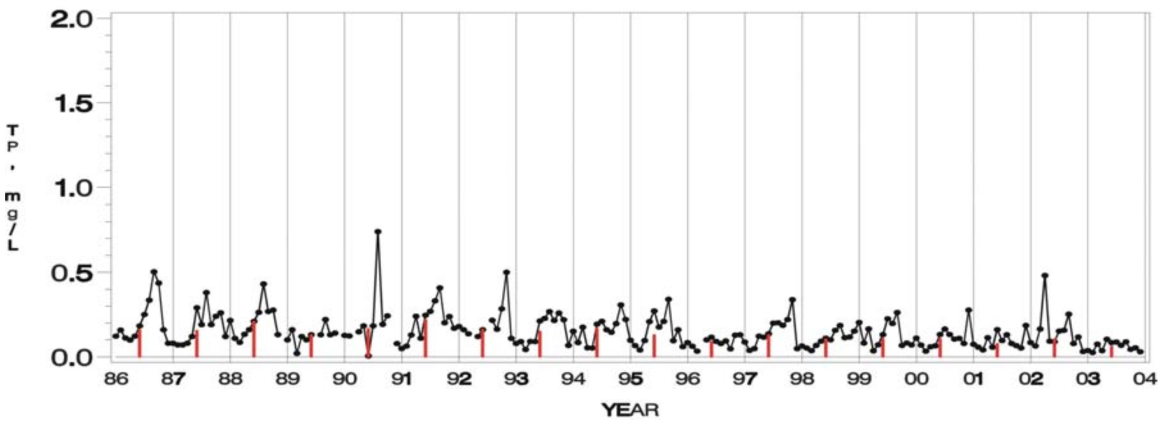

Total Phosphorus at POT1595 (Point of Rocks – MD), 1986–2003, layer=S
red bar = annual median
TP, mg/L
YEAR


Total Susp. Solids at POT1595 (Point of Rocks – MD), 1986–2003, layer=S
red bar = annual median
TSS, mg/L
YEAR

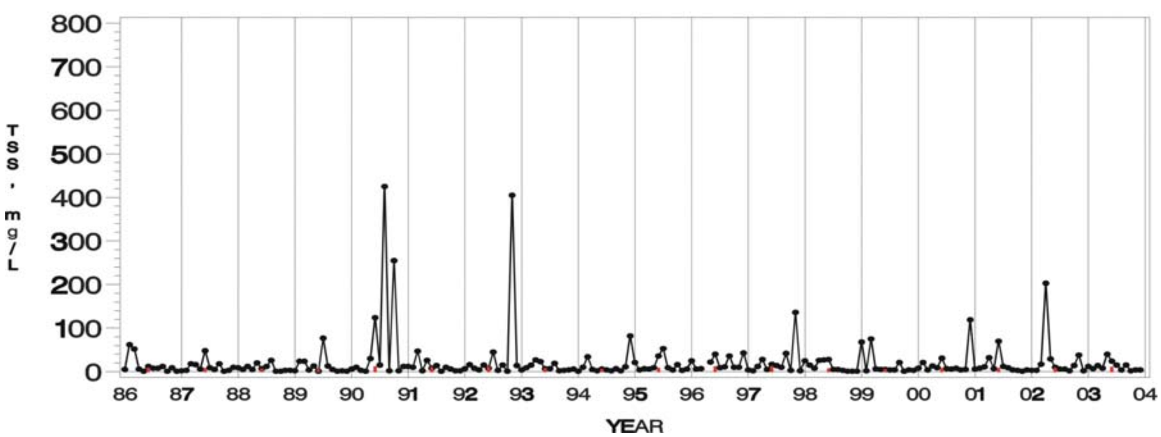
Total Nitrogen at CON0180 (PA Line), 1986−2003, layer=S
red bar = annual median

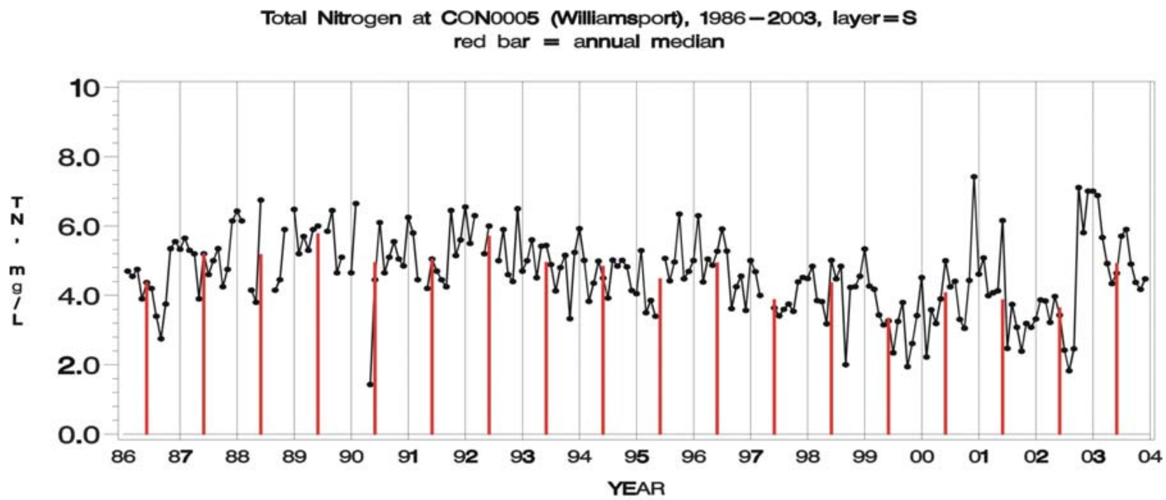


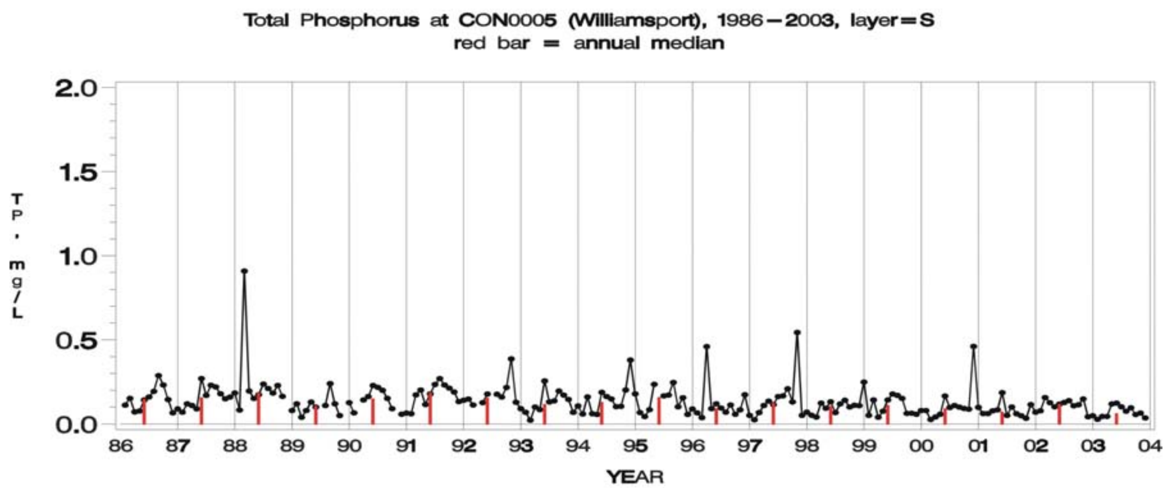
Total Phosphorus at CON0180 (PA Line), 1986−2003, layer=S
red bar = annual median

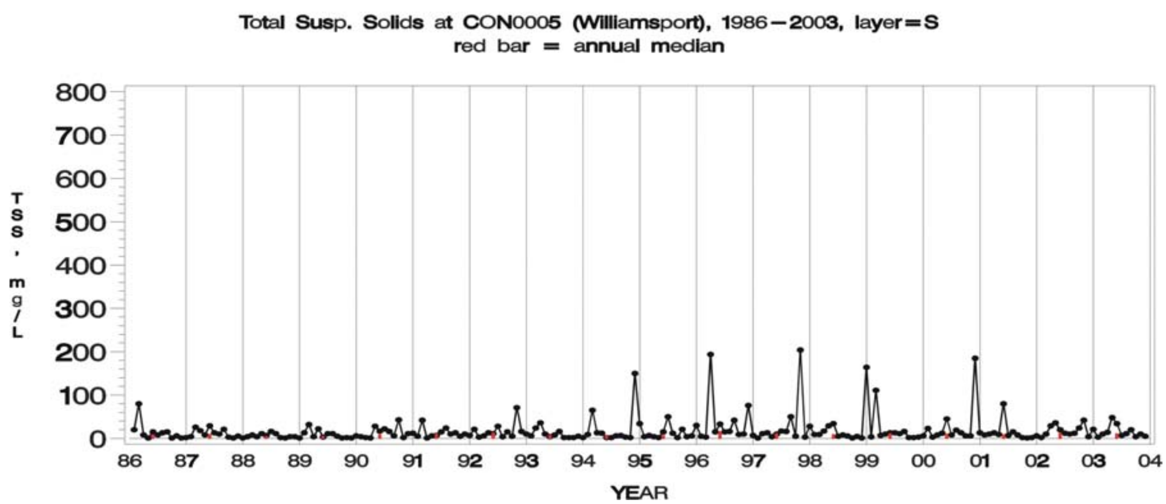


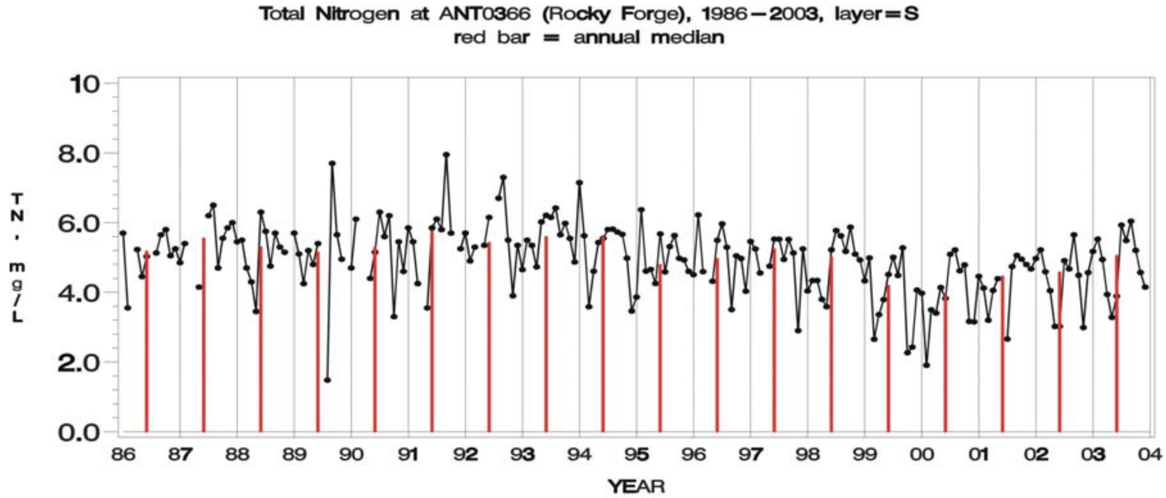
Total Susp. Solids at CON0180 (PA Line), 1986−2003, layer=S
red bar = annual median

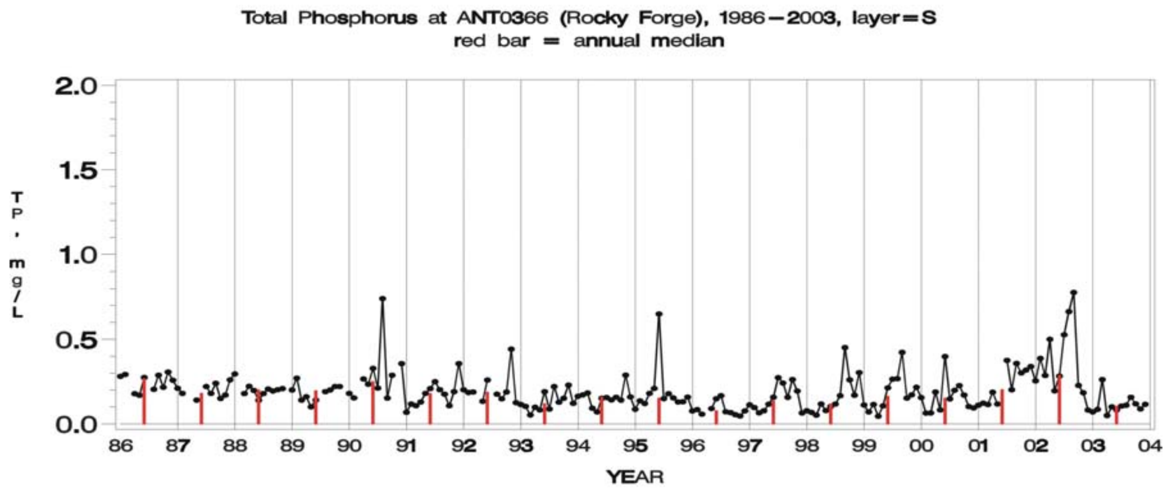


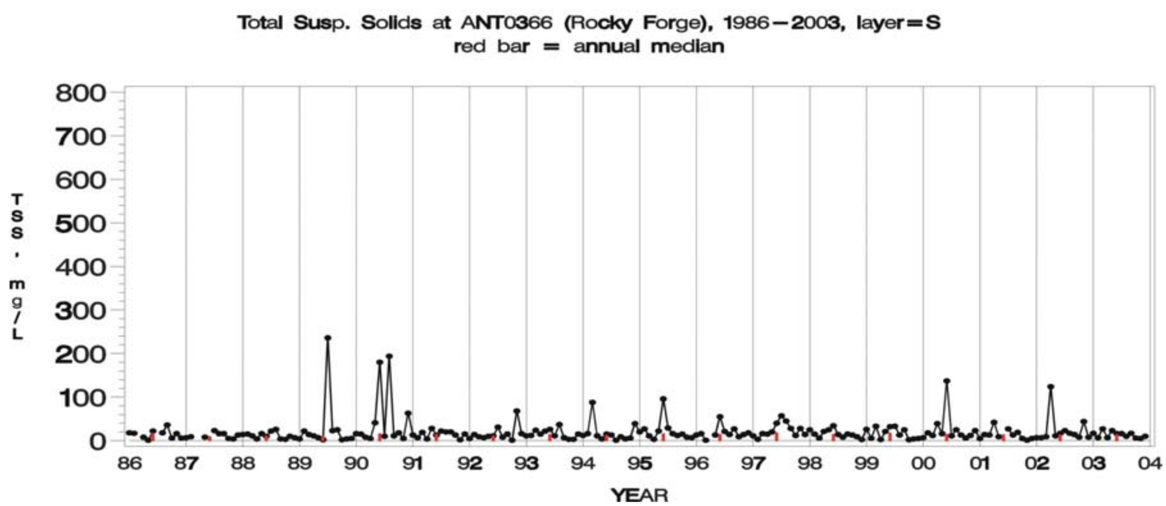

Total Nitrogen at CON0005 (Williamsport), 1986-2003, layer=S
red bar = annual median
TN, mg/L
YEAR

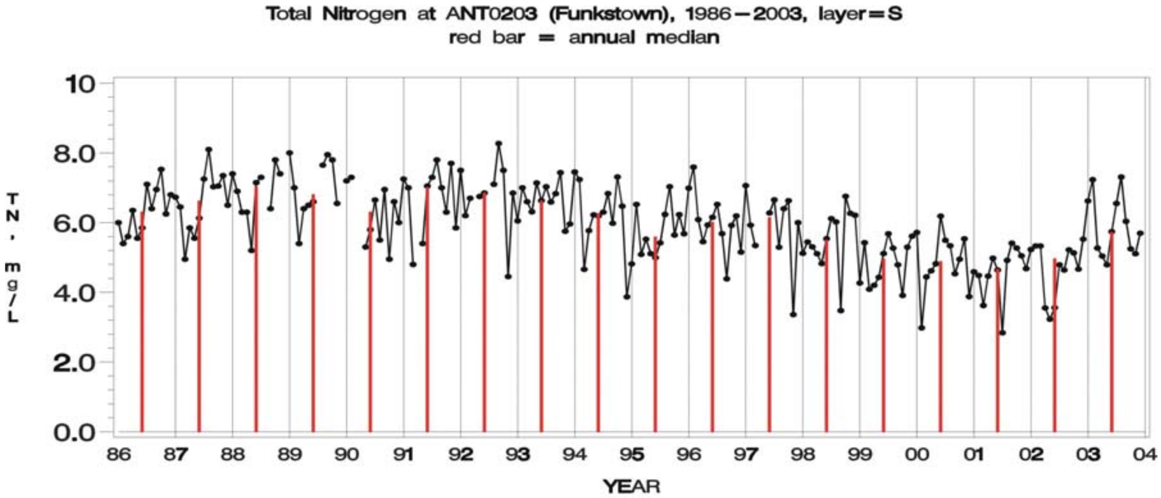

Total Phosphorus at CON0005 (Williamsport), 1986-2003, layer=S
red bar = annual median
TP, mg/L
YEAR

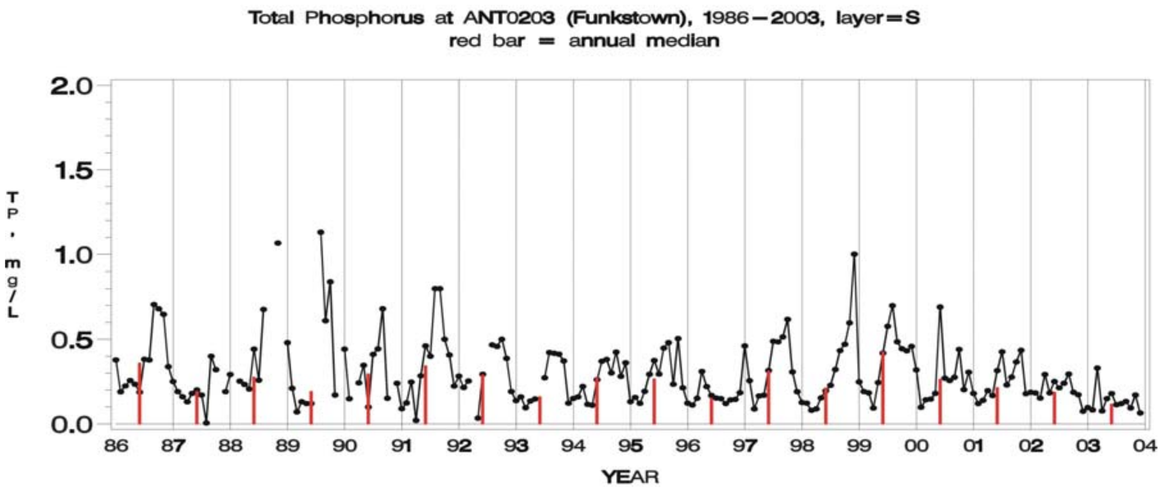

Total Susp. Solids at CON0005 (Williamsport), 1986-2003, layer=S
red bar = annual median
TSS, mg/L
YEAR

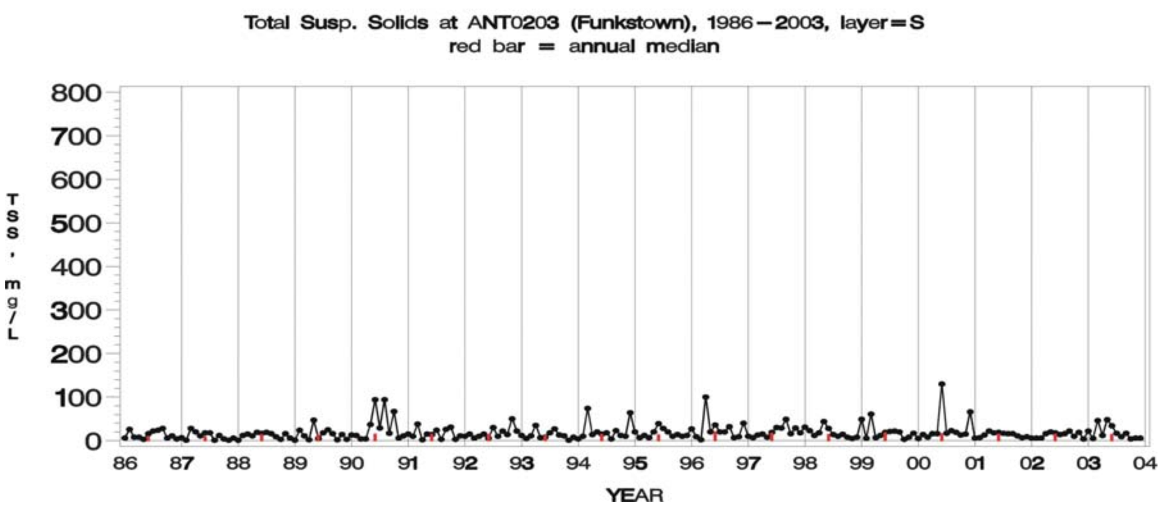

Total Nitrogen at ANT0366 (Rocky Forge), 1986-2003, layer=S
red bar = annual median
TN - mg/L
YEAR

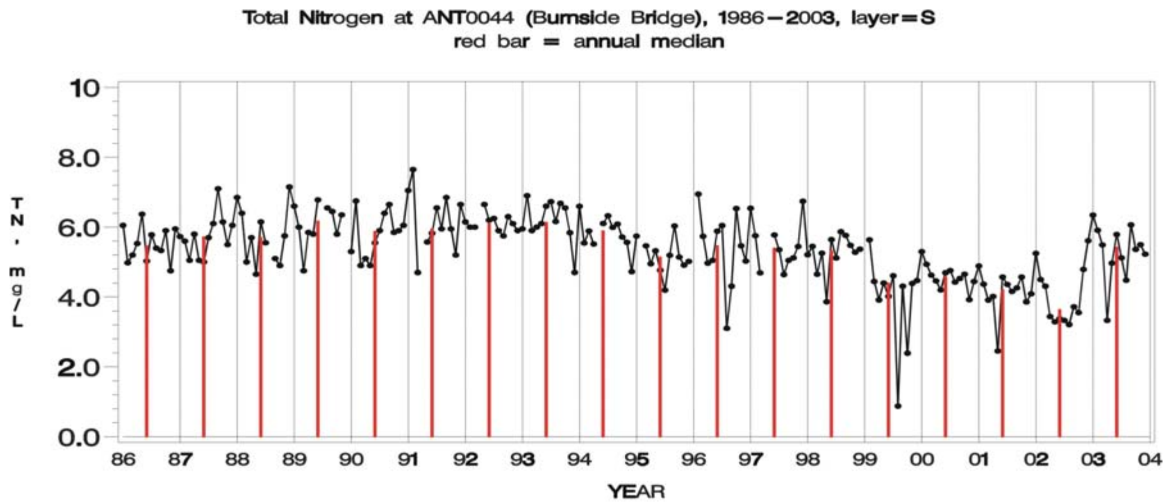

Total Phosphorus at ANT0366 (Rocky Forge), 1986-2003, layer=S
red bar = annual median
TP - mg/L
YEAR

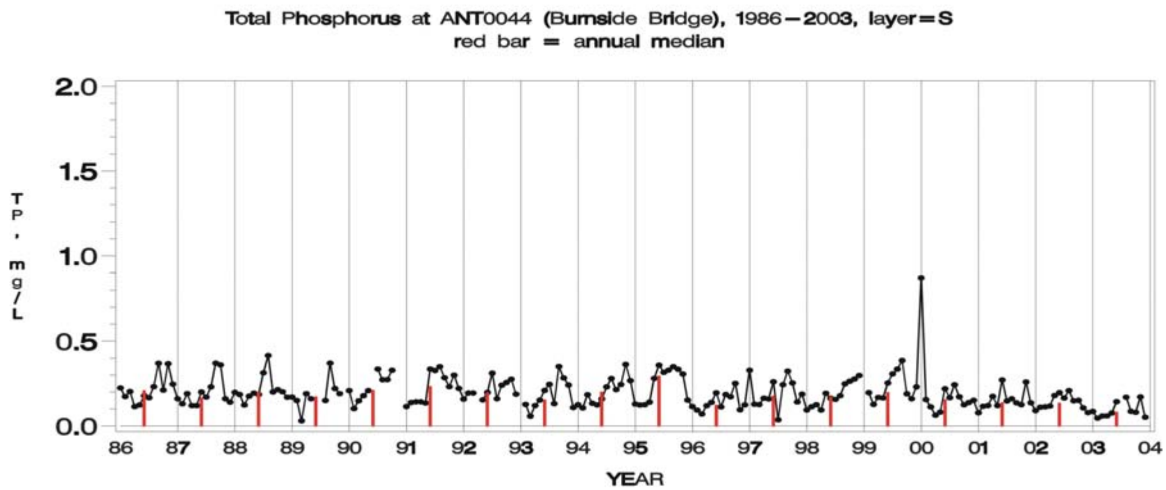

Total Susp. Solids at ANT0366 (Rocky Forge), 1986-2003, layer=S
red bar = annual median
TSS - mg/L
YEAR

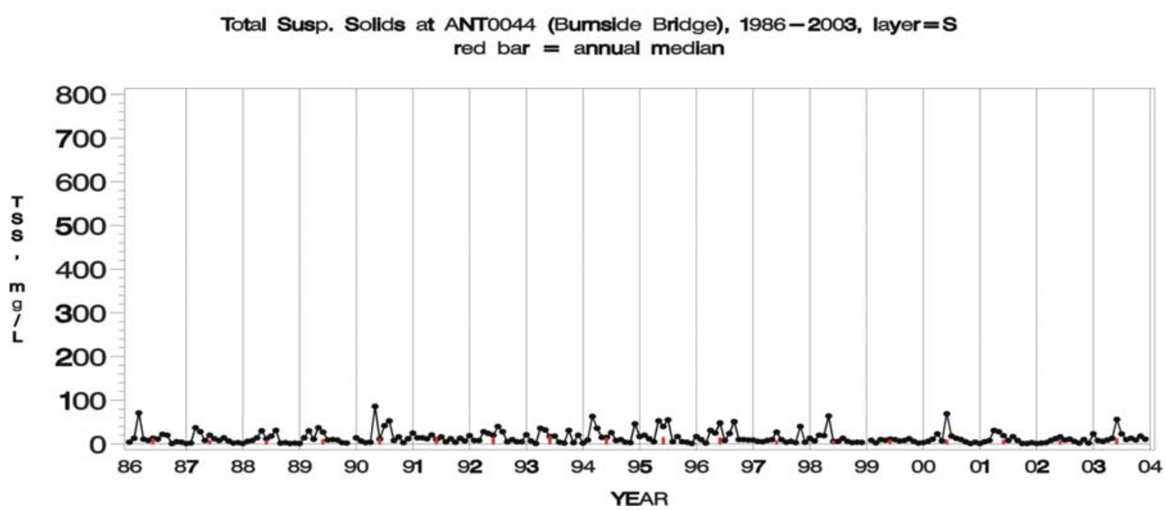

Total Nitrogen at ANT0203 (Funkstown), 1986–2003, layer=S
red bar = annual median
TN, mg/L
10
8.0
6.0
4.0
2.0
0.0
86
87
88
89
90
91
92
93
94
95
96
97
98
99
00
01
02
03
04
YEAR

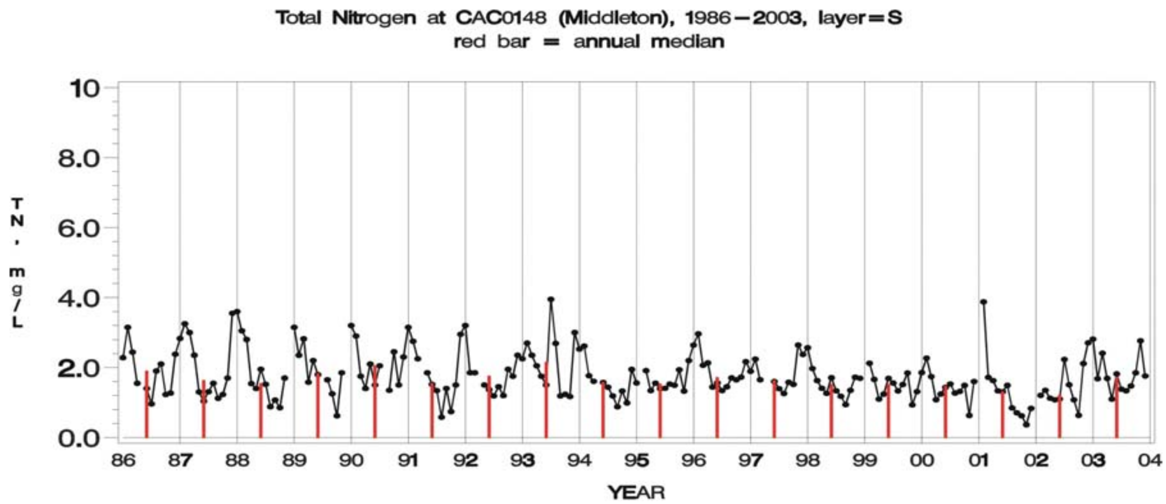

Total Phosphorus at ANT0203 (Funkstown), 1986–2003, layer=S
red bar = annual median
TP, mg/L
2.0
1.5
1.0
0.5
0.0
86
87
88
89
90
91
92
93
94
95
96
97
98
99
00
01
02
03
04
YEAR

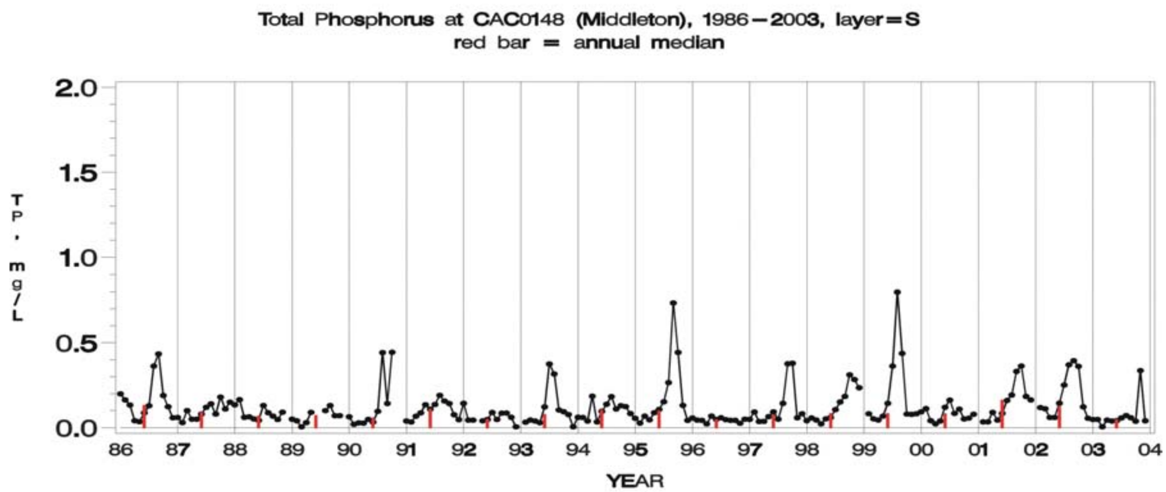

Total Susp. Solids at ANT0203 (Funkstown), 1986–2003, layer=S
red bar = annual median
TSS, mg/L
800
700
600
500
400
300
200
100
0
86
87
88
89
90
91
92
93
94
95
96
97
98
99
00
01
02
03
04
YEAR

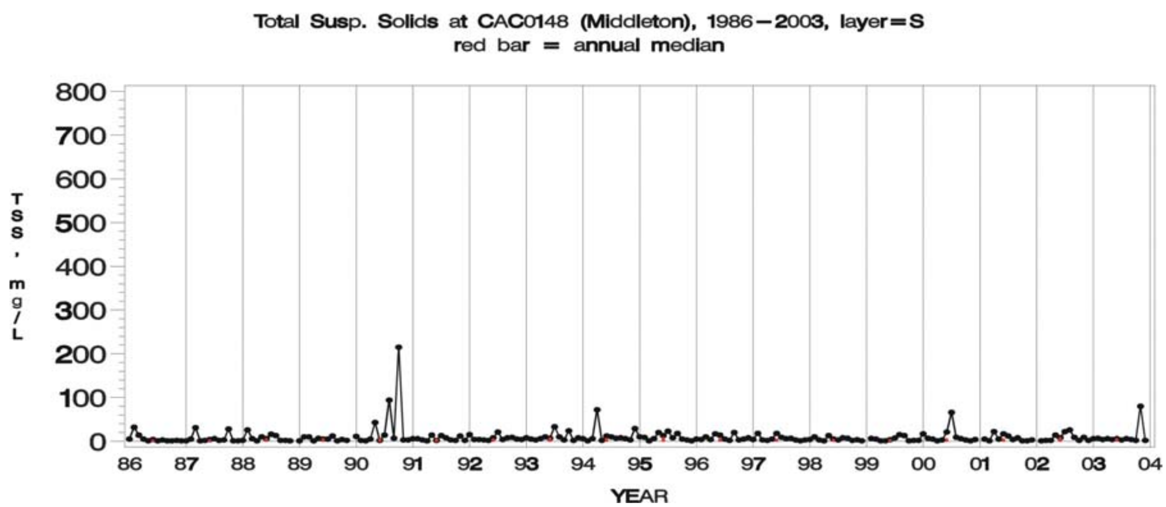

Total Nitrogen at ANT0044 (Burnside Bridge), 1986-2003, layer=S
red bar = annual median
TN, mg/L
10
8.0
6.0
4.0
2.0
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Phosphorus at ANT0044 (Burnside Bridge), 1986-2003, layer=S
red bar = annual median
TP, mg/L
2.0
1.5
1.0
0.5
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

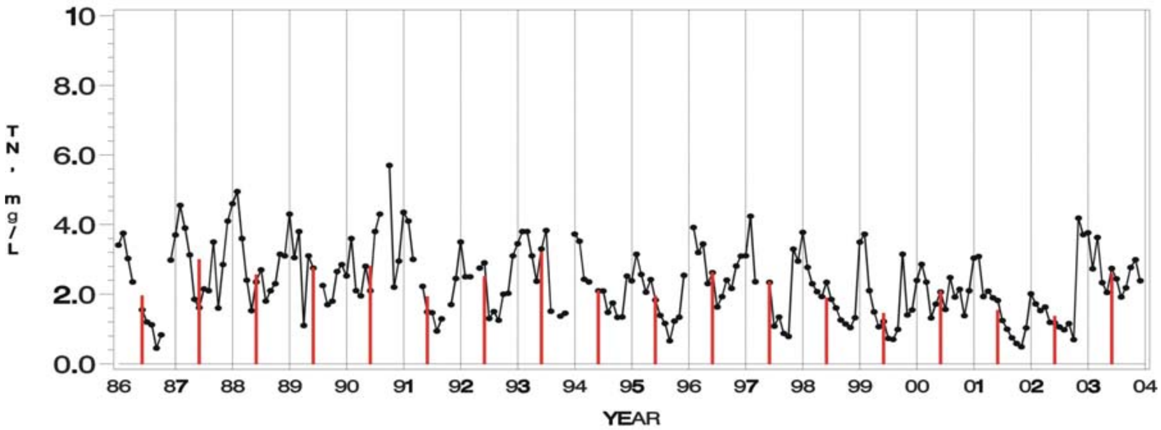

Total Susp. Solids at ANT0044 (Burnside Bridge), 1986-2003, layer=S
red bar = annual median
TSS, mg/L
800
700
600
500
400
300
200
100
0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Nitrogen at CAC0148 (Middleton), 1986−2003, layer=S
red bar = annual median
10
8.0
6.0
4.0
2.0
0.0
TN, mg/L
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

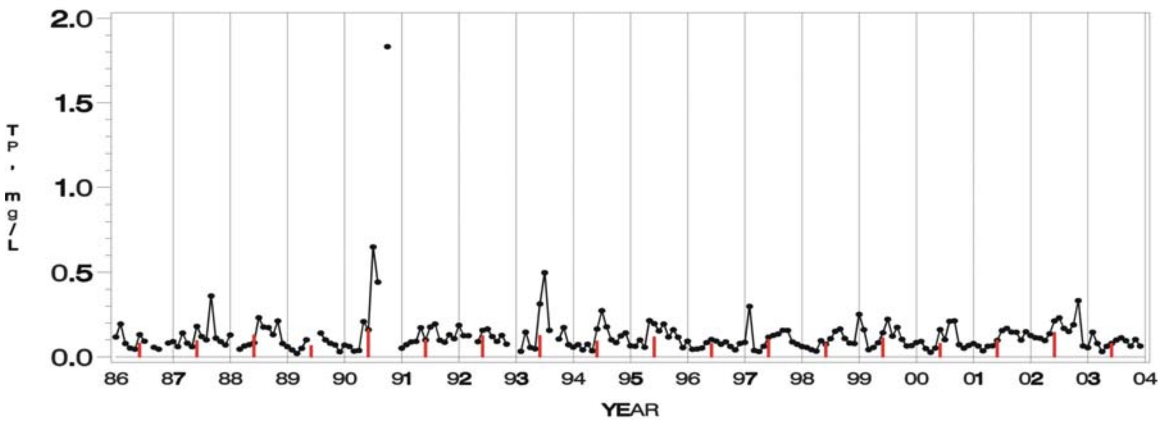

Total Phosphorus at CAC0148 (Middleton), 1986−2003, layer=S
red bar = annual median
2.0
1.5
1.0
0.5
0.0
TP, mg/L
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Susp. Solids at CAC0148 (Middleton), 1986−2003, layer=S
red bar = annual median
800
700
600
500
400
300
200
100
0
TSS, mg/L
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

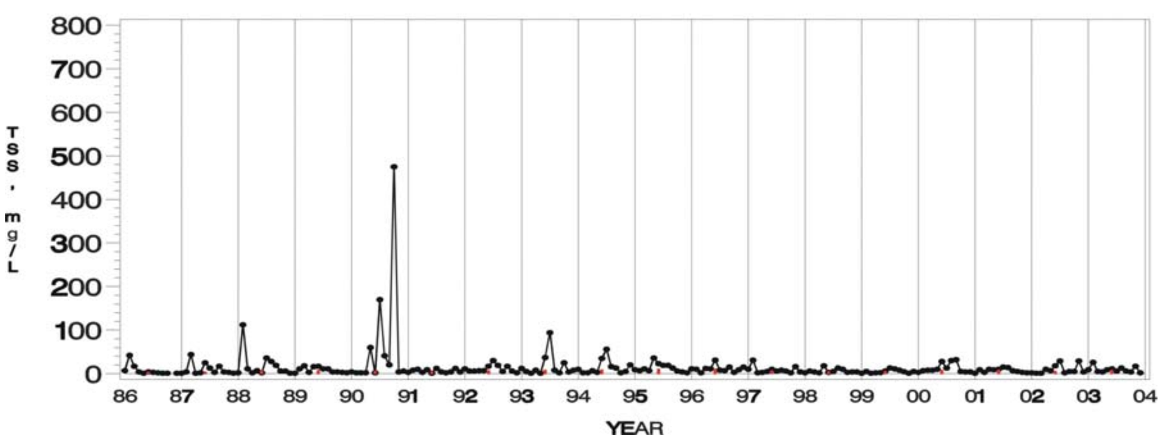
Total Nitrogen at CAC0031 (Route 464), 1986-2003, layer=S
red bar = annual median

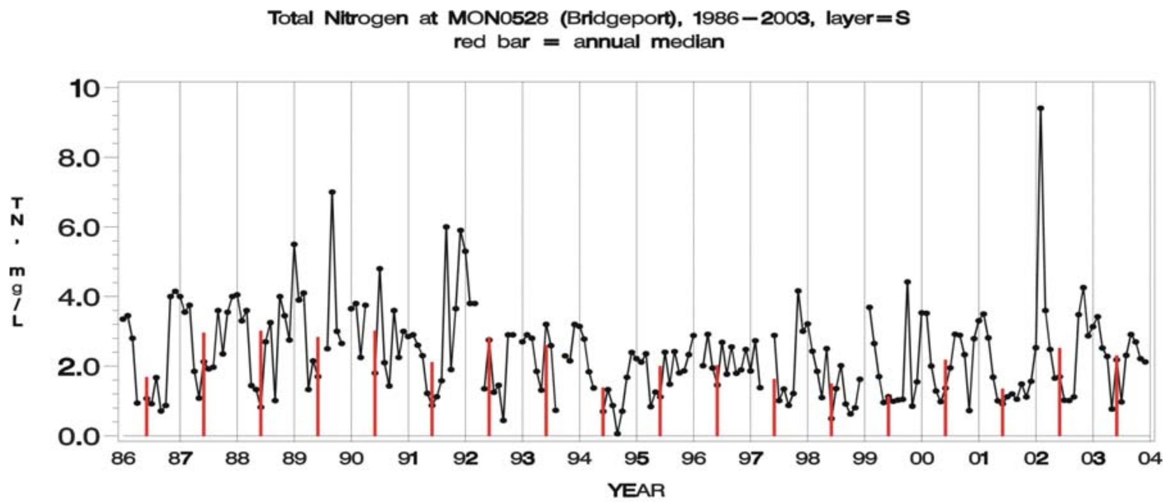


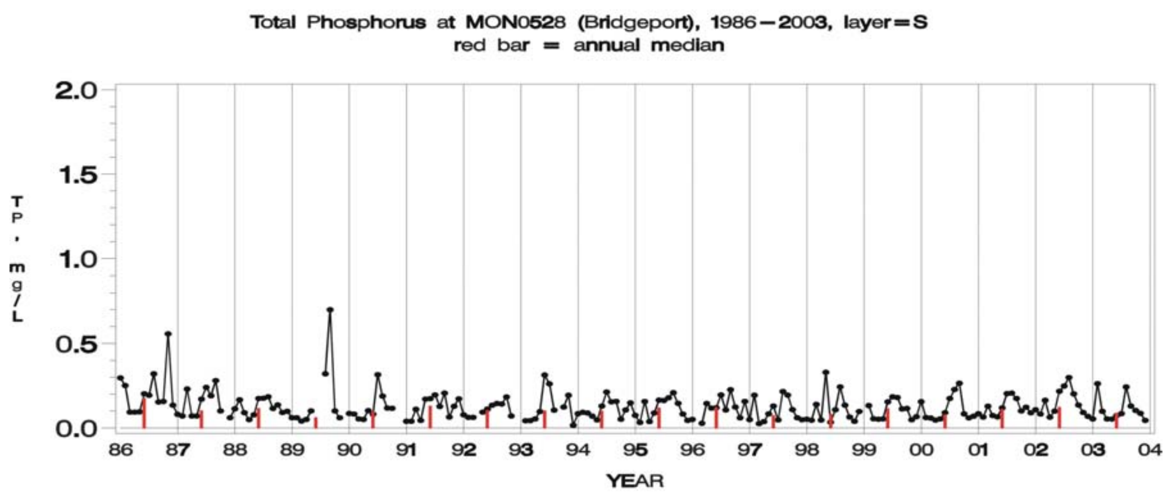
Total Phosphorus at CAC0031 (Route 464), 1986-2003, layer=S
red bar = annual median

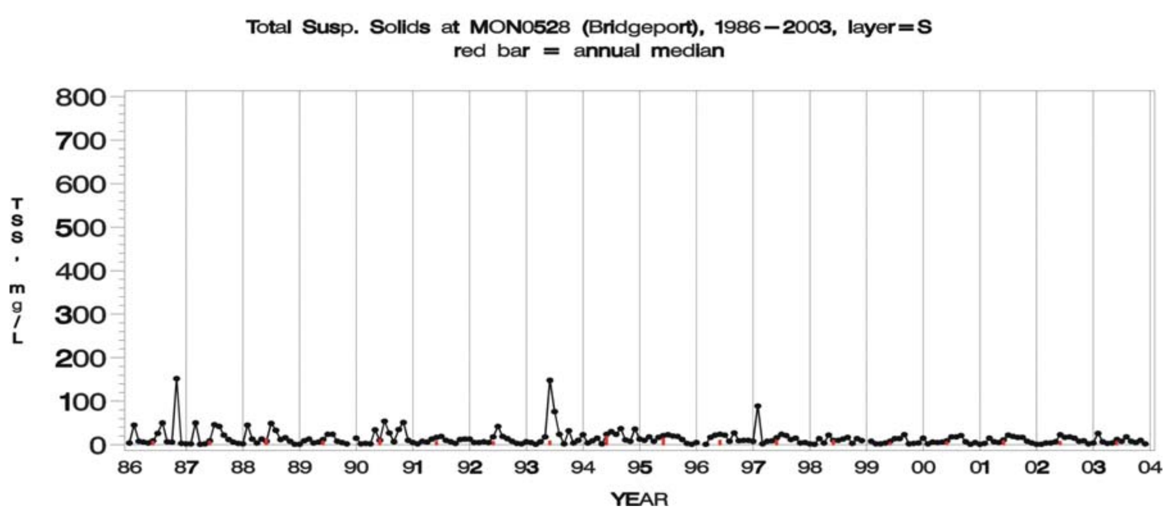


Total Susp. Solids at CAC0031 (Route 464), 1986-2003, layer=S
red bar = annual median

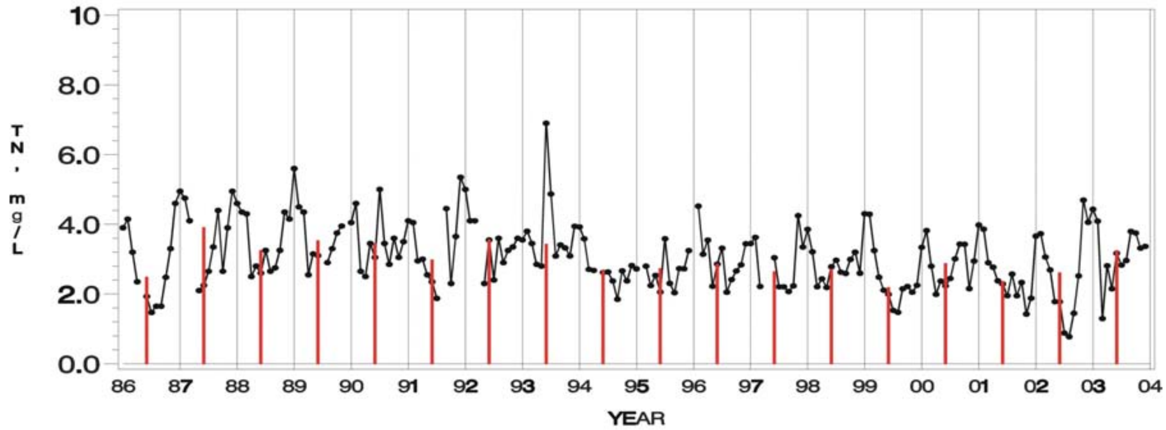



Total Nitrogen at MON0528 (Bridgeport), 1986-2003, layer=S
red bar = annual median
TN, mg/L
10
8.0
6.0
4.0
2.0
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

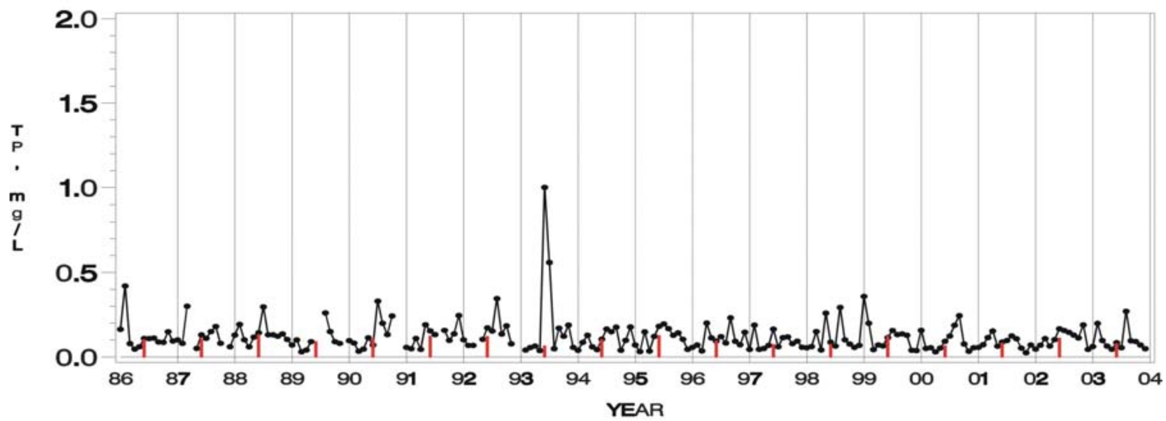

Total Phosphorus at MON0528 (Bridgeport), 1986-2003, layer=S
red bar = annual median
TP, mg/L
2.0
1.5
1.0
0.5
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR


Total Susp. Solids at MON0528 (Bridgeport), 1986-2003, layer=S
red bar = annual median
TSS, mg/L
800
700
600
500
400
300
200
100
0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

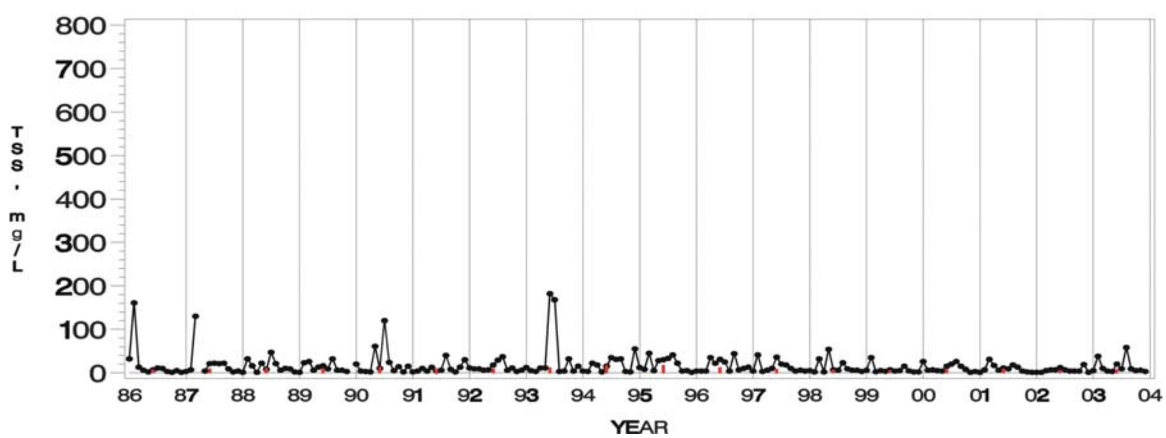
Total Nitrogen at MON0269 (Biggs Ford), 1986−2003, layer=S
red bar = annual median

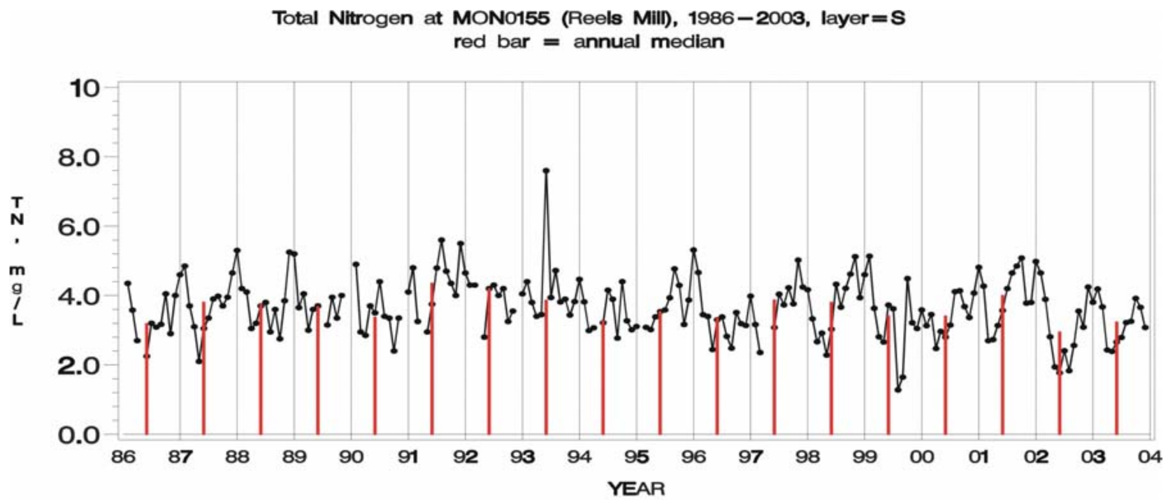


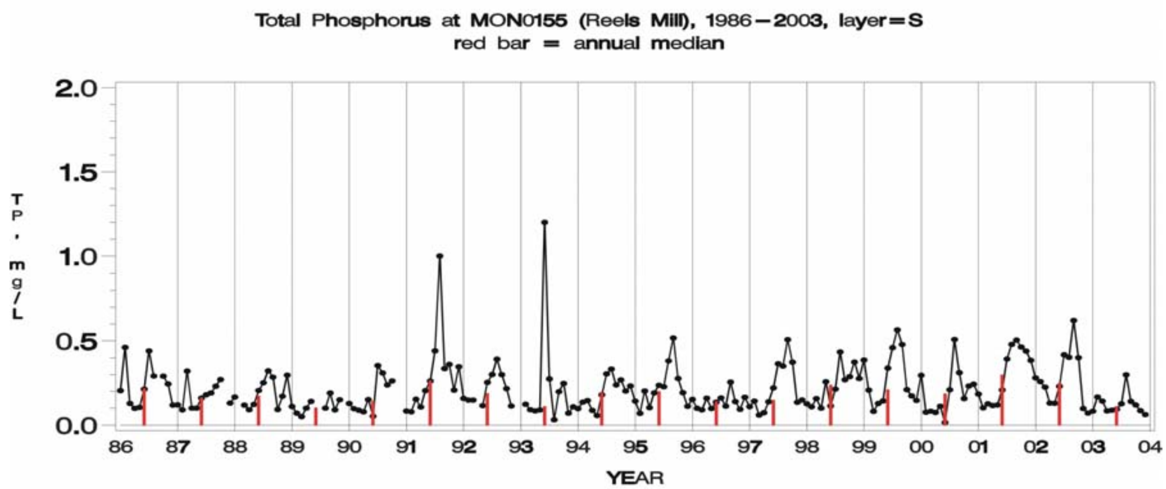
Total Phosphorus at MON0269 (Biggs Ford), 1986−2003, layer=S
red bar = annual median

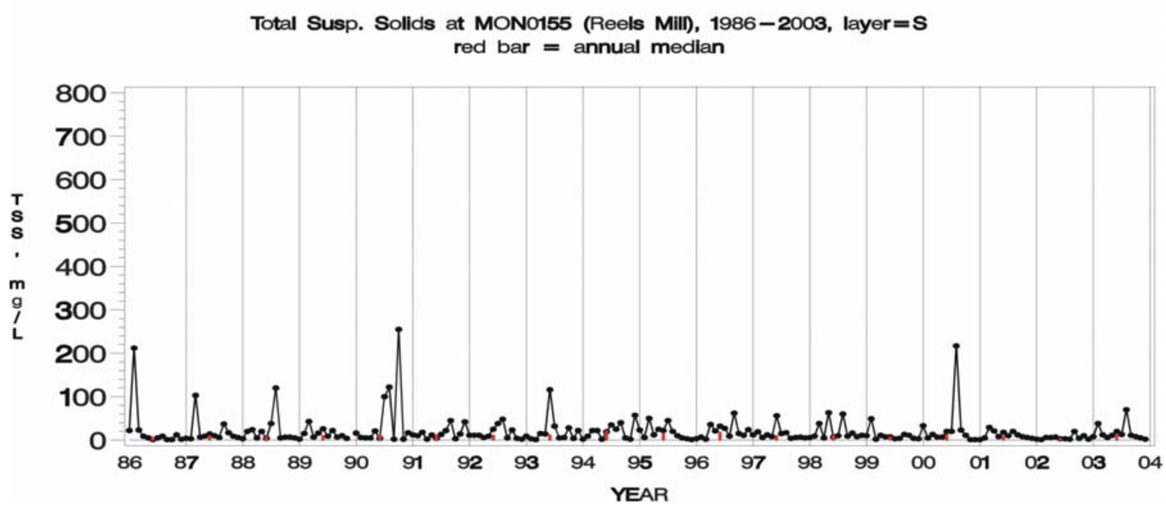


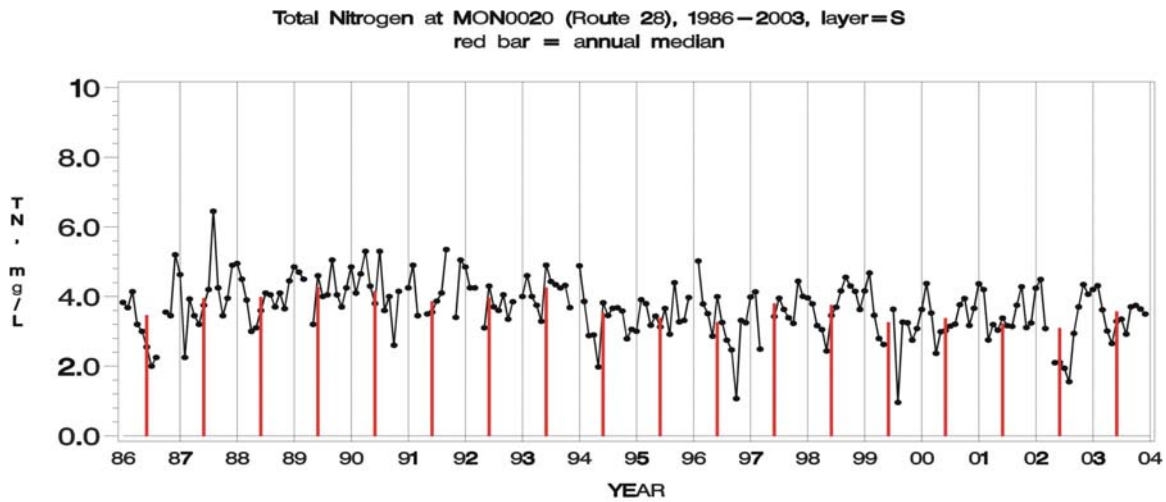
Total Susp. Solids at MON0269 (Biggs Ford), 1986−2003, layer=S
red bar = annual median

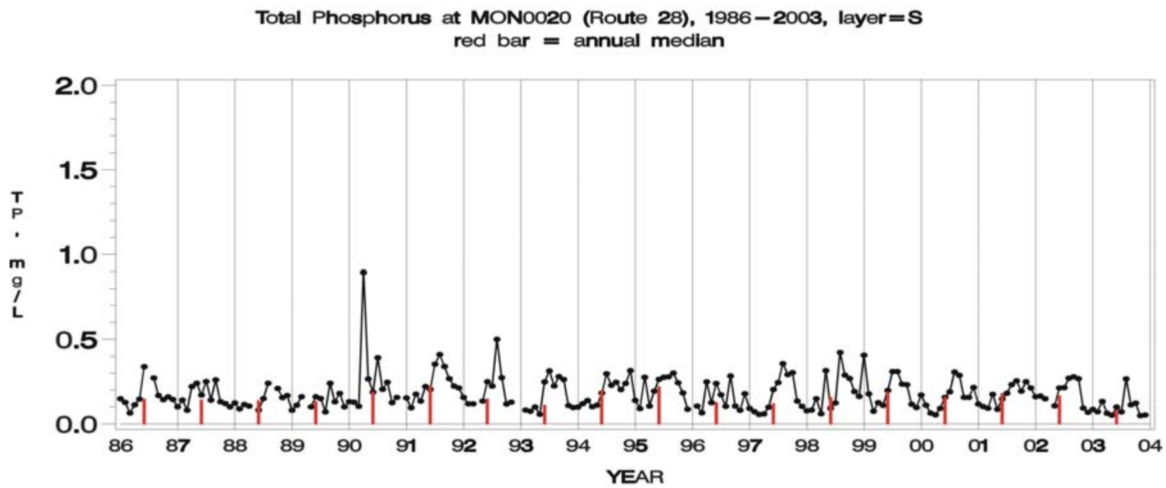


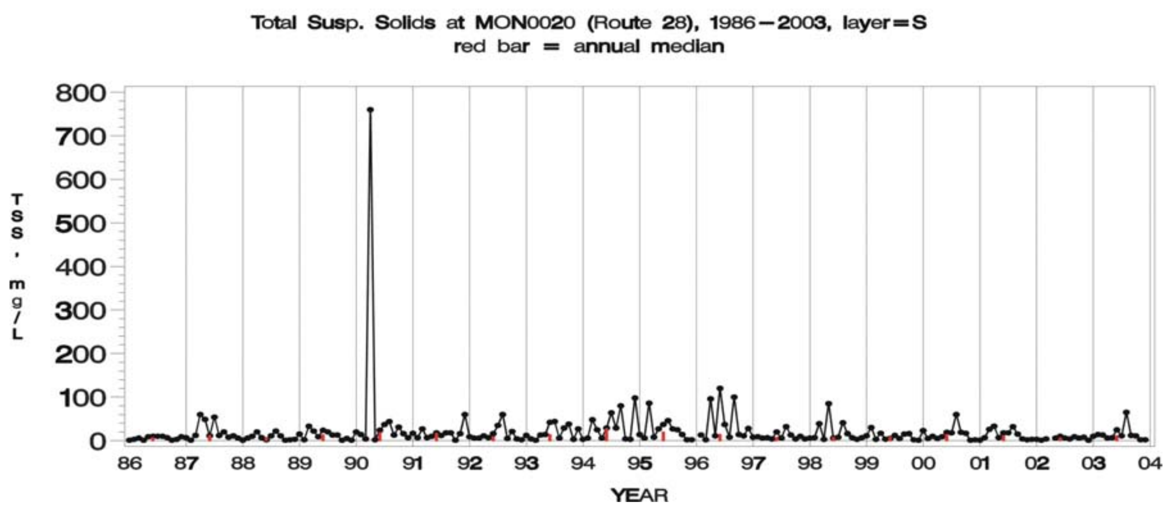

Total Nitrogen at MON0155 (Reels Mill), 1986−2003, layer=S
red bar = annual median
TN, mg/L
10
8.0
6.0
4.0
2.0
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

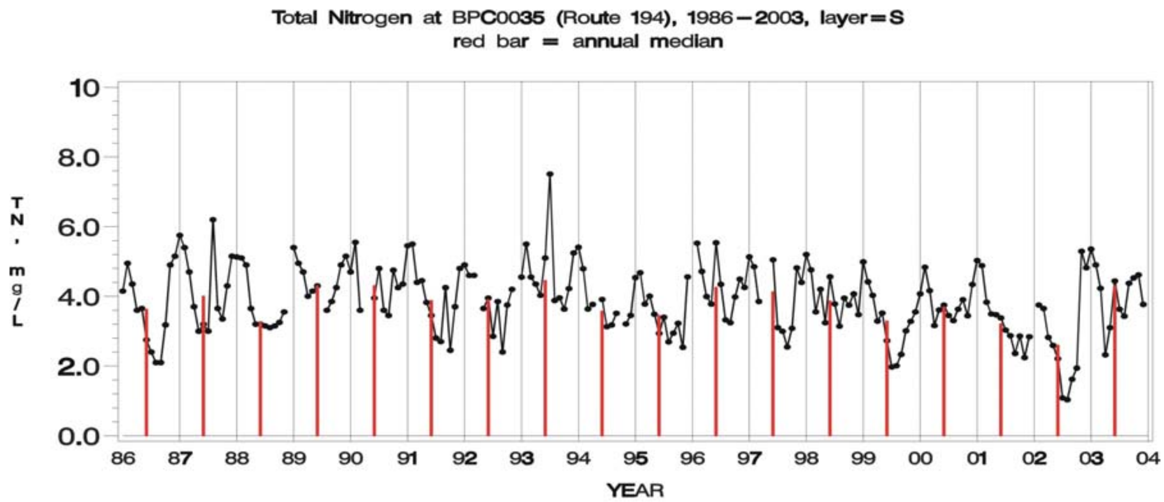

Total Phosphorus at MON0155 (Reels Mill), 1986−2003, layer=S
red bar = annual median
TP, mg/L
2.0
1.5
1.0
0.5
0.0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

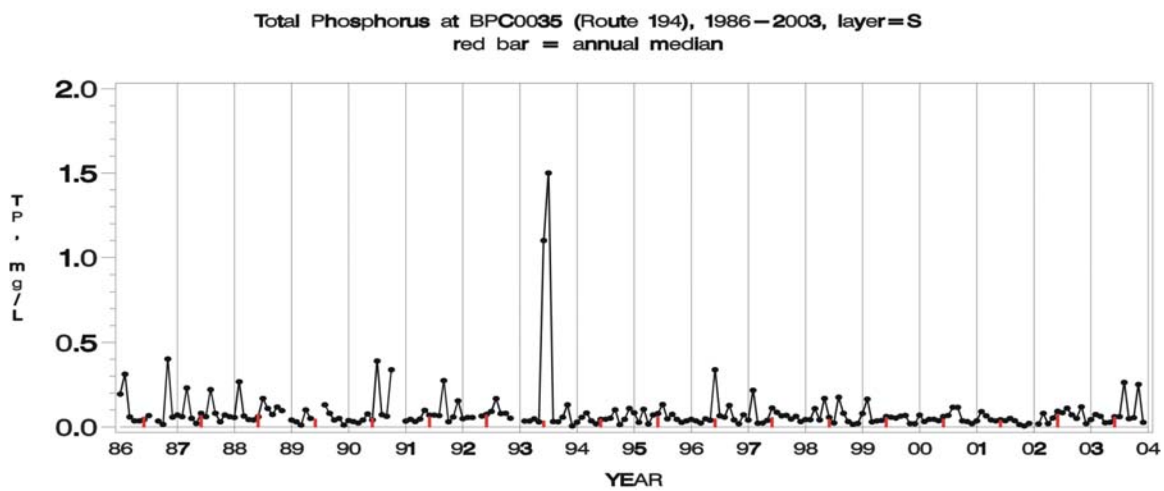

Total Susp. Solids at MON0155 (Reels Mill), 1986−2003, layer=S
red bar = annual median
TSS, mg/L
800
700
600
500
400
300
200
100
0
86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04
YEAR

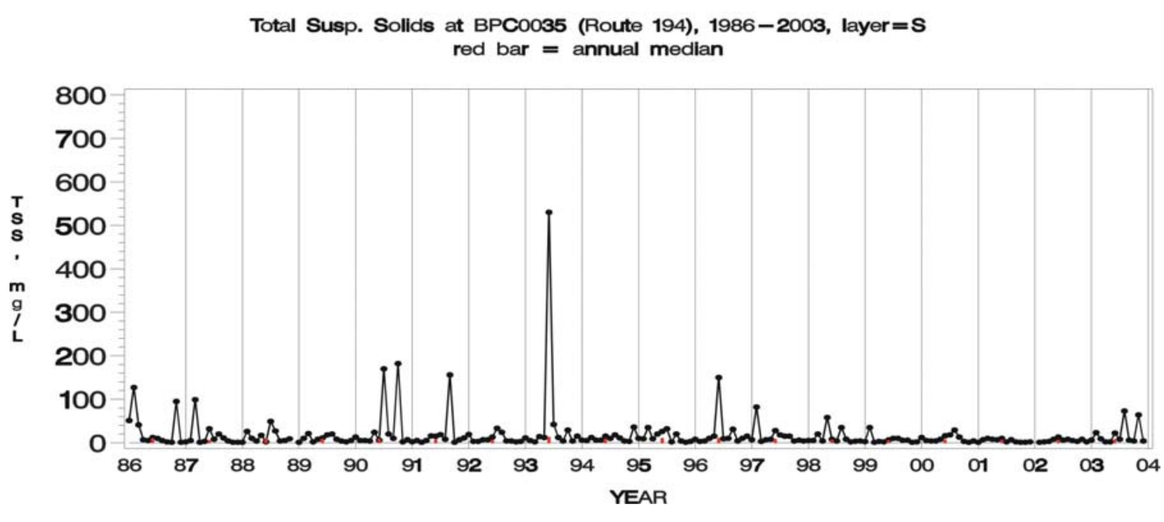

Total Nitrogen at MON0020 (Route 28), 1986–2003, layer=S
red bar = annual median
TN, mg/L
YEAR


Total Phosphorus at MON0020 (Route 28), 1986–2003, layer=S
red bar = annual median
TP, mg/L
YEAR


Total Susp. Solids at MON0020 (Route 28), 1986–2003, layer=S
red bar = annual median
TSS, mg/L
YEAR


Total Nitrogen at BPC0035 (Route 194), 1986-2003, layer=S
red bar = annual median
TN, mg/L
YEAR


Total Phosphorus at BPC0035 (Route 194), 1986-2003, layer=S
red bar = annual median
TP, mg/L
YEAR


Total Susp. Solids at BPC0035 (Route 194), 1986-2003, layer=S
red bar = annual median
TSS, mg/L
YEAR

Appendix C – Nutrient Limitation Text

Nutrient limitation information is collected only in the tidal areas of the Potomac, so there is no information for the Upper Potomac River.

Appendix D – Glossary

algae bloom – high concentrations of phytoplankton (algae).

benthos – bottom-dwellers.

dinoflagellates – a type of flagellated single-celled phytoplankton; most are photosynthesizers but some are also heterotrophic.

epiphytic – growing on a plant. Epiphytic algae grow on the leaves and stems of bay grasses.

estuary – a semi-enclosed, tidal, coastal body where fresh water running off land mixes with salt water coming in from the ocean.

hypoxia – the condition of low dissolved oxygen (< 2 mg/L), which is detrimental to many living organisms.

nauplius – an early planktonic stage in the life of a crustacean.

nutrient – chemicals required for plant growth and reproduction; in this report the term nutrients generally refers to nitrogen and phosphorus.

plankton - organisms that are unable to swim strongly, and drift along with currents; many are microscopic

phytoplankton – plankton that are "plant-like" in that they are primarily or partially autotrophic (primary producers); many are tiny single-celled organisms; examples include diatoms and dinoflagellates.

tributary – a stream, creek or river that feeds into a larger body of water.

watershed – a basin that drains into a particular body of water.

zooplankton – plankton that tend to be "animal-like" in that they are primarily heterotrophic (e.g., they eat other organisms); examples include copepods and rotifers.

Appendix E – References

Van Belle, G. and J. P. Hughes. 1984. Nonparametric tests for trend in water quality. Water Resources Research 20:127-136.